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CONCEPT DESIGN REPORT. METAL PARTS FURNACE.(U)

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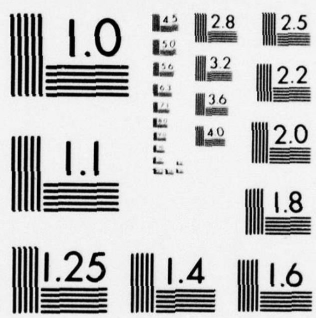

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METAL PARTS FURNACE
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ENGINEERING ACCOMPLISHMENT REPORT

FINAL CONCEPT DESIGN REPORT

Data Item A010

and

SPECIFICATIONS

Data Item A001

prepared by

SURFACE COMBUSTION DIVISION
MIDLAND-ROSS CORPORATION

For

OFFICE OF THE PROJECT MANAGER FOR
CHEMICAL DEMILITARIZATION AND
INSTALLATION RESTORATION
ABERDEEN PROVING GROUND, MARYLAND 21010

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Concept design report of a thermal detoxification system for the safe disposal of a lethal chemical agents. Includes a Failure Mode and Hazardous Effects Analysis and a Human Factors Engineering Report.

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METAL PARTS FURNACE
DAAA15-74-C-0092

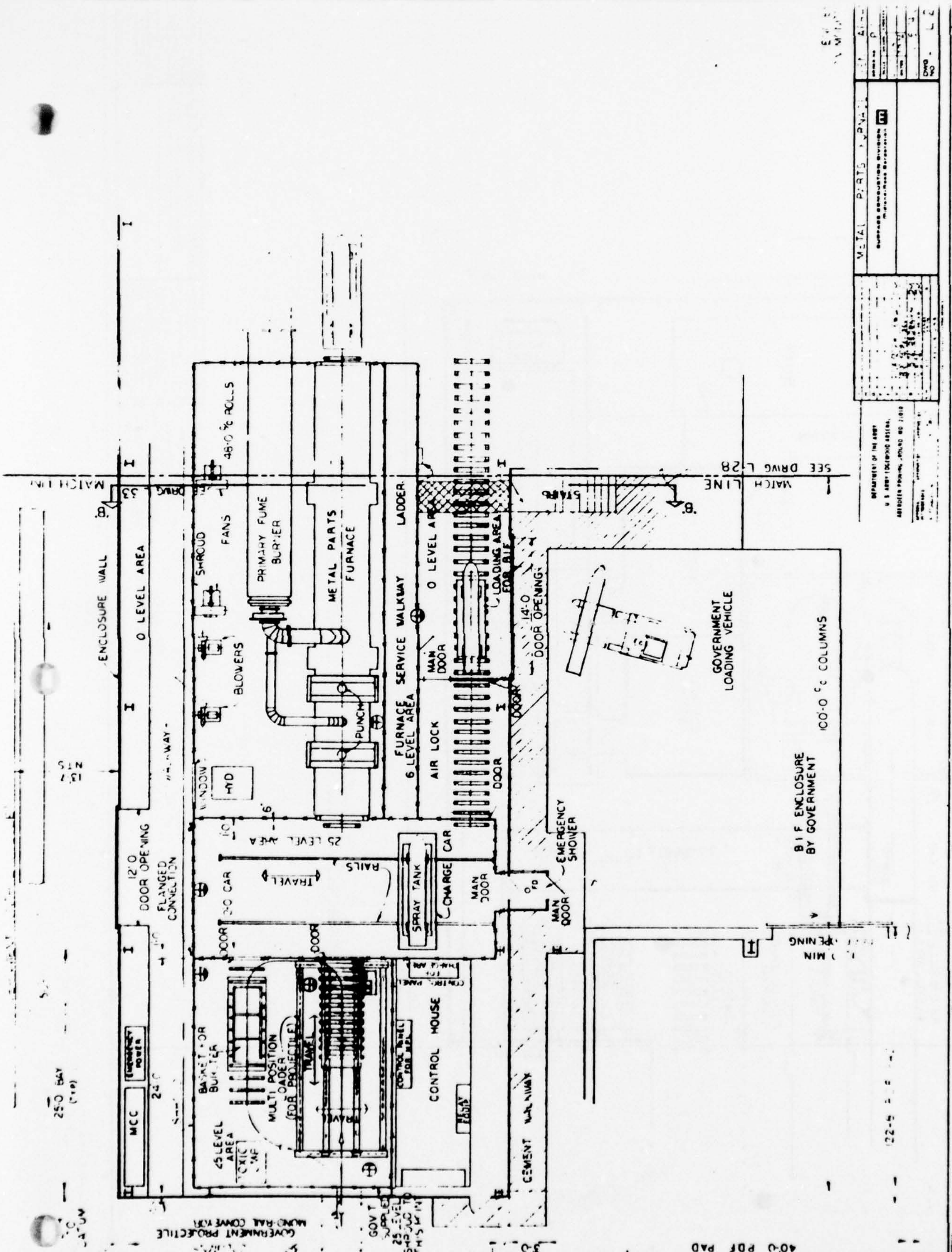
FINAL CONCEPT DESIGN SUMMARY

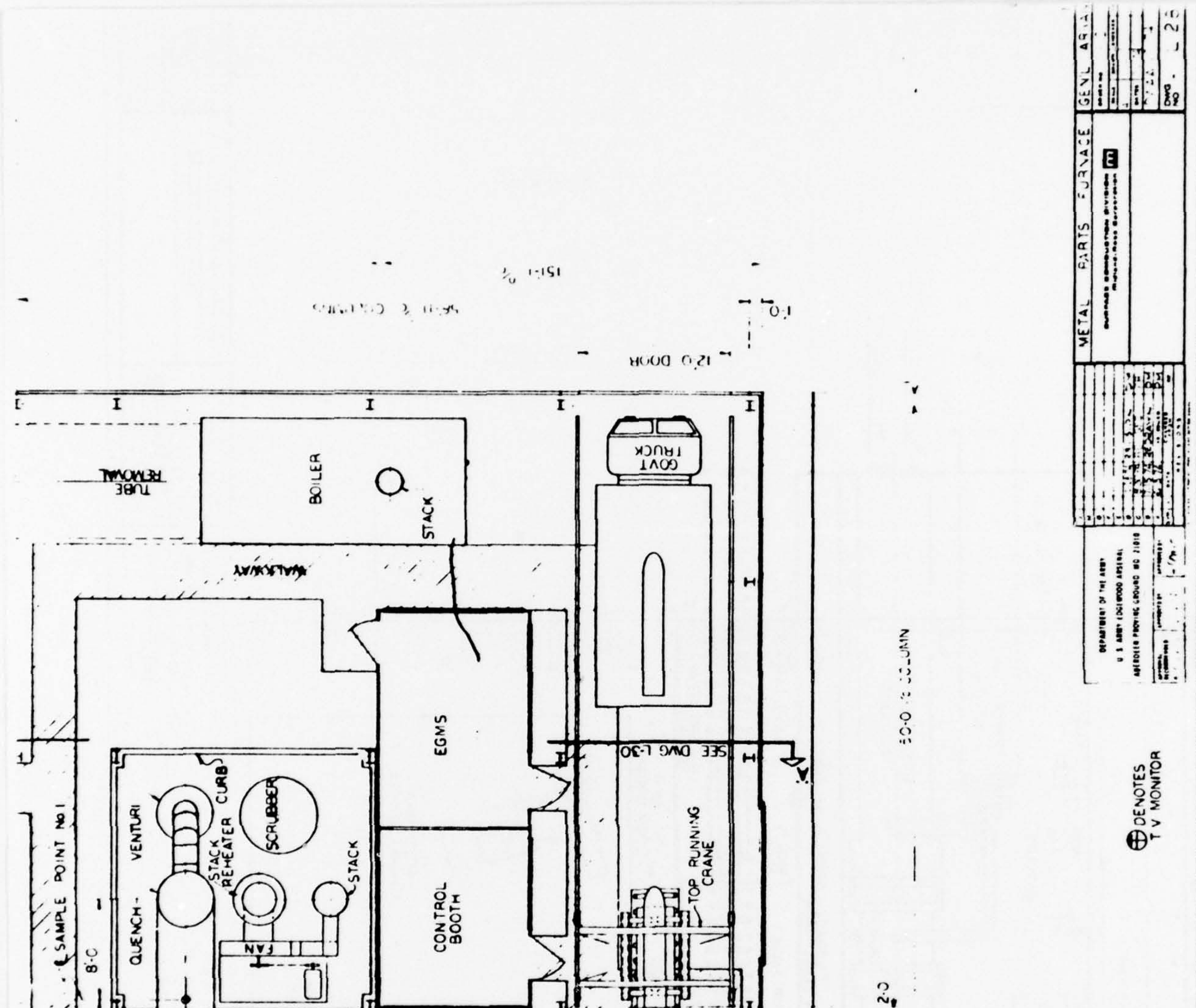
The challenge of the CAMDS Metal Parts Furnace concept design study included finding solutions to a number of difficult problems. The primary requirement is to design a thermal detoxification system to achieve certification of the effluents which include flue gases, scrap metal parts and inorganic salt products. The detoxification operations must be performed in a total containment environment with adaptability for the variety of items and chemical agents specified for demilitarization in the CAMDS Facility. Flue gas emission control is of great importance and must meet the strictest regulations of the Army Environmental Health Agency as well as the Environmental Protection Agency. The total operation is to be highly mechanized and remotely controlled to conform with the most up to date human factors requirements.

The Metal Parts Furnace final concept design for the CAMDS Demil Facility features a single continuous processing furnace, separate fume burners for destruction of toxic vapors and an air pollution control system for treatment of the exhaust gases. The furnace is designed to process both filled or drained munitions and bulk items with a vestibule for ventilated punching of the bulk items a controlled volatilization chamber and a final burn-out chamber. This arrangement includes the necessary material handling equipment to suit the variety of munitions scheduled for processing included in the CAMDS Design Specification.

Physical arrangement of the entire Metal Parts System is shown graphically on the three (3) General Arrangement Drawings, sheets L-27, L-28 and L-37. The overall arrangement of the equipment is shown schematically on the General Process Schematic Drawing, sheet L-20. Reduced size versions of these drawings are included as a part of this design summary report. Full size prints are included with the Final Concept Design Drawing Package, data item A003.

A rather complicated material handling problem is simplified using a modularized work tray which serves as a common carrier for bulk items, projectiles, and scrap parts. The work tray is built up using four (4) alloy steel tray castings, each 2'-0 long x 3'-0 wide to make an 8'-0 long x 3'-0 wide tray. Sufficient trays will be provided to allow for a tray to serve each of the work processing positions with extra trays for loading. unloading and positioning. A series of simple fixtures will be provi-- to customize the system for handling the variety of metal part shapes specified.


ENCLOSURE WALL
O LEVEL AREA
WALKWAY
12'-0 DOOR OPENING
FLANGED CONNECTION
MCC
EMERGENCY POWER
SHROUD
FANS
BLOWERS
PRIMARY FUME BURNER
METAL PARTS FURNACE
PUNCH
48'-0 C-C ROLLS
HYD
WINDOW
LADDER
FURNACE SERVICE WALKWAY
6 LEVEL AREA
AIR LOCK
MAN DOOR
DOOR
O LEVEL AREA
LOADING AREA FOR BIF
14'-0 DOOR OPENING
STAIRS
SEE DRWG L-28
MATCH LINE
25 LEVEL AREA
RAILS
TRAVEL
SPRAY TANK
CHARGE CAR
MAN DOOR
EMERGENCY SHOWER
BASKET FOR BURSTER
MULTI POSITION LOADER (FOR PROJECTILE)
25 LEVEL AREA
CONTROL HOUSE
CEMENT WALKWAY
GOVERNMENT PROJECTILE MONO-RAIL CONVEYOR
GOVERNMENT LOADING VEHICLE
100'-0 C-C COLUMNS
BIF ENCLOSURE BY GOVERNMENT
40'-0 PDF PAD
METAL PARTS FURNACE
DEPARTMENT OF THE ARMY



METAL PARTS FURNACE
GEN'L AREA
DEPARTMENT OF THE ARMY
U S ARMY EDGEWOOD ARSENAL
ABERDEEN PROVING GROUND MD 21010
TUBE REMOVAL
BOILER
STACK
GOVT TRUCK
12'0 DOOR
WALKWAY
EGMS
CONTROL BOOTH
SEE DWG L-30
50'-0 ℄ COLUMN
TOP RUNNING CRANE
SCRUBBER
CURB
VENTURI
STACK REHEATER
STACK
QUENCH
FAN
SAMPLE POINT NO 1
8'-0
12'-0 CAR
GUARD RAIL
DISCHARGE CAR
TRAVEL
RAILS
STOPS
WALKWAY
25'-0
℄ BURNER
48'-0 ℄ ROLLS
6' LEVEL AREA
AUXILIARY FUME BURNER
METAL PARTS FURNACE
FURNACE SERVICE WALKWAY
LADDER
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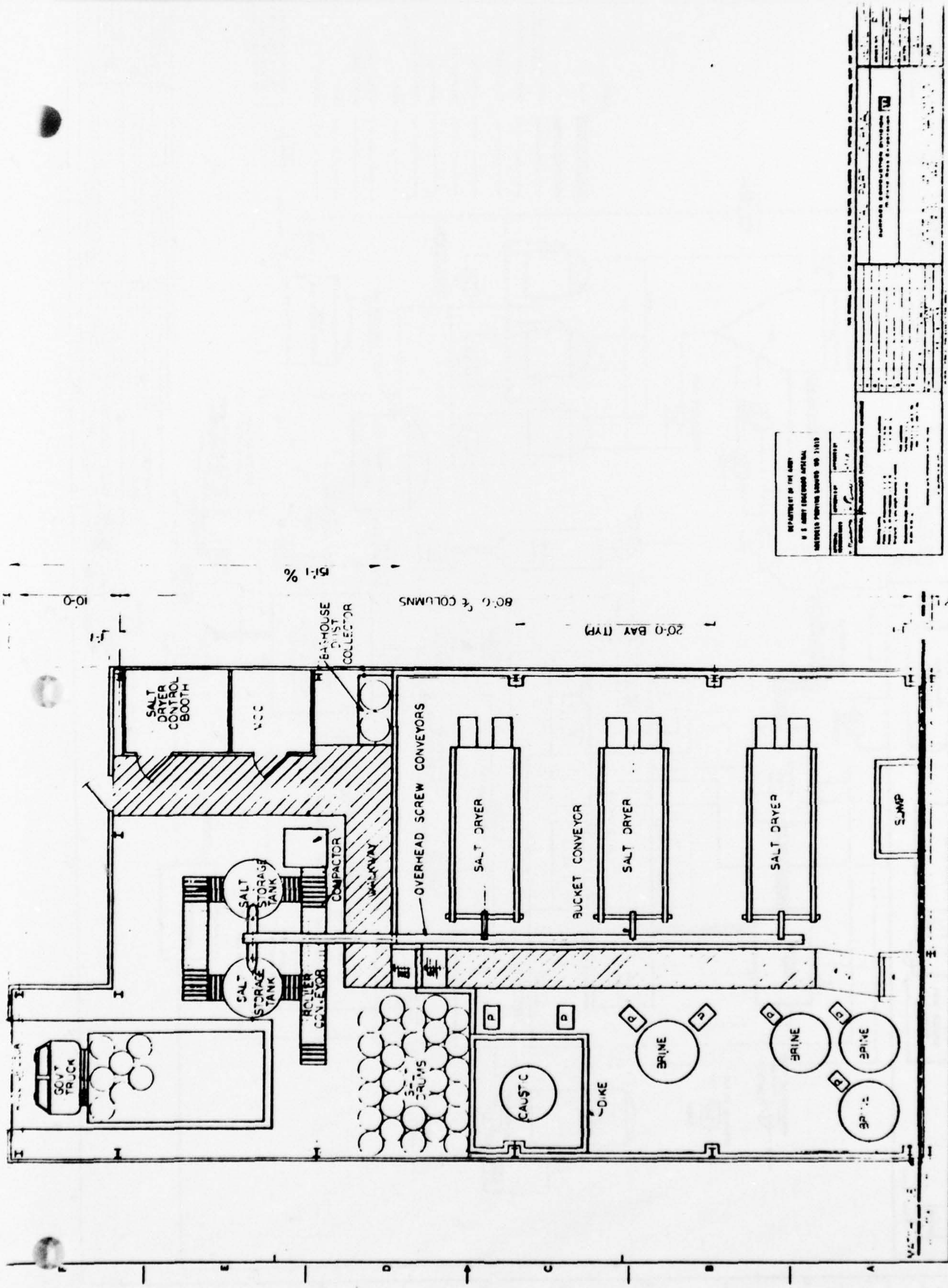
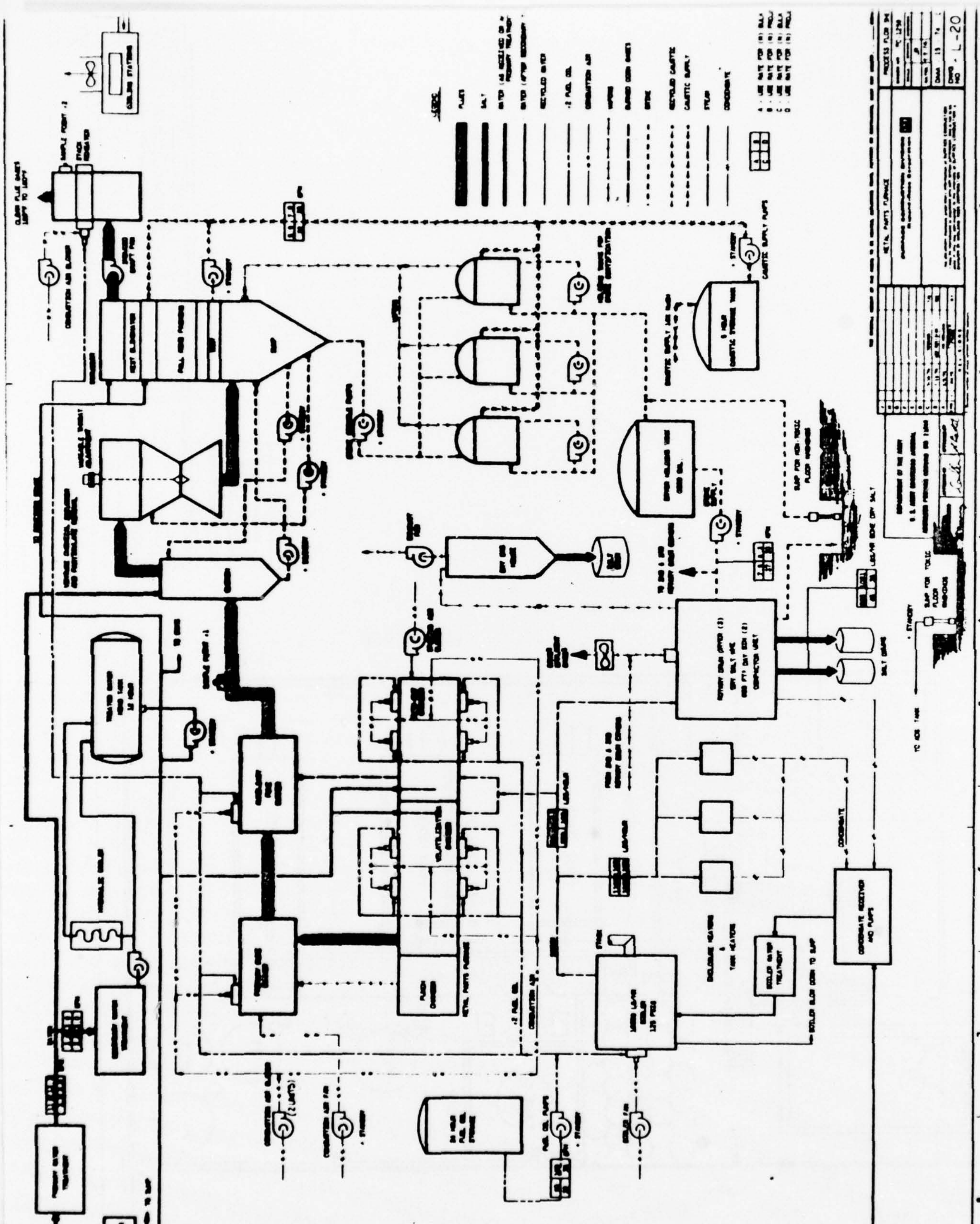
LOUVERS
COOLING STATION
COOLING STATION
100'-0 ℄ COLUMNS
SEE DWG L-27
MATCH LINE
DENOTES T V MONITOR


SALT DRYER CONTROL BOOTH
MCC
BAGHOUSE DUST COLLECTOR
OVERHEAD SCREW CONVEYORS
SALT DRYER
BUCKET CONVEYOR
SALT DRYER
SALT DRYER
SUMP
SALT STORAGE TANK
COMPACTOR
WALKWAY
ROLLER CONVEYOR
SALT DRUMS
GOVT TRUCK
CAUSTIC
DIKE
BRINE
BRINE
BRINE
20'-0 BAY (TYP)
80'-0 ℄ COLUMNS
10'-0



Loaded trays are moved to, through, and away from the furnace on roller conveyors and powered charge and discharge cars. The powered charge and discharge cars accomplish the necessary switching, transverse handling and reversing motions to complete the tray handling circuit. The trays are moved through the furnace on powered rollers as readily as they are moved outside of the furnace. Positive positioning within the furnace chambers is achieved through the use of mechanical flag switches which stop the work tray in the exact position required for a particular process operation.

The fixtured tray handling concept was selected because of the adaptability required to suit the variety of munition sizes and shapes and because it is especially well suited to supporting the filled projectiles with the open or burster well end vertically up. These same trays are adapted to bulk item processing using tray fixtures. Burster wells from the PDR are contained in a basket style fixture which mounts on the same work tray.

For punching the bulk items, a twin punch arrangement is provided as an integral part of the furnace punching chamber. This punching is completely enclosed, having a gas tight external door. The punching operation takes place within this enclosed chamber. Special punch-vent collars are provided to capture toxic gases which may escape when the internal pressure of a bulk item container is relieved as it is punched. Gases from the punch-vent collars are ducted directly to the primary fume burner (PFB) for safe disposal.

This Metal Parts Furnace (MPF) is unique in that it can process both Mustard <u>filled</u> projectiles and bulk items! This is accomplished with a "controlled evaporation" technique with incineration of the Mustard vapors in a separate chamber. Following the "controlled evaporation" step, the munitions move into a separate burn-out chamber for the thermal treatment required for certification. The separation of the process steps is depicted on Figure 1, "Schematic Diagram". Drained GB and VX munitions are processed using the same equipment.

Fumes from both the punching chamber and the volatilization chamber flow directly to a primary fume burner (PFB) for incineration. Flue gases from the PFB and the burn-out chamber are ducted to an auxiliary fume burner (AFB) for final afterburning at a nominal temperature of 1600 F. The gaseous residence time in the PFB exhaust duct is 0.5 seconds. An additional 0.5 seconds residence time is provided downstream of the AFB.

Flue products from the fume burners are cooled by direct contact water sprays in the counterflow quench chamber. From the quench chamber, the gases flow into a high energy venturi scrubber followed by a packed tower and a demister section. Motive power for the gas flow circuit is provided by an induced draft exhaust fan. Gases leaving the fan rise vertically

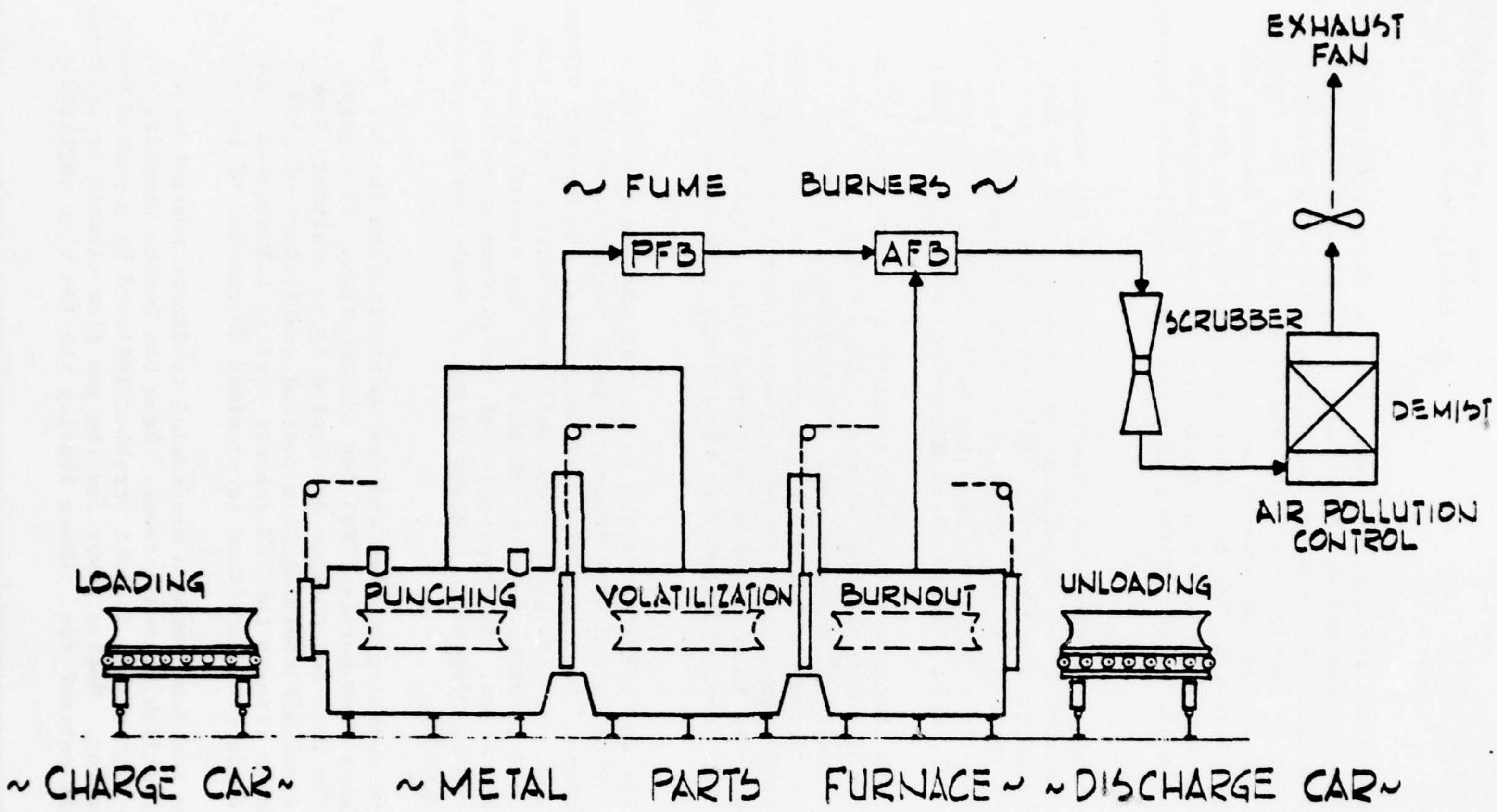


FIGURE 1 SCHEMATIC DIAGRAM
PROCESSING MUSTARD FILLED TON CONTAINERS

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MIDLAND ROSS CORP
MAY 20, 1974

through a stack equipped for continuous monitoring. A stack reheater is included for steam plume abatement when adverse ambient conditions prevail.

A NaOH caustic solution is used as the scrubbing liquid in the venturi and packed tower. The spent caustic brine is removed to a series of certification holding tanks. Following certification, the brine is pumped to an evaporator for extraction of the salts. Conservation of process water is accomplished by control of gas temperatures leaving the vertical quench tower and by closed loop condensate return piping to the boiler/condensate receiver system. In addition, process particulates from the double drum salt dryer knives are captured on the dry side of the knives and vented to a dry type baghouse dust collector.

Detoxified scrap metal parts are removed from the furnace and air cooled using power convection in the cooling chambers. This cooling air is exhausted outside to avoid over heating the enclosure. After cooling, the scrap is removed and the trays are returned for reloading. Large scrap items are loaded into trucks using a remotely operated bi-rail crane and hoist. Projectiles are lifted with magnet and truck loaded with an overhead type crane. The entire scrap handling system is remotely controlled for operator safety.

A complete enclosure provides protection from the elements. This enclosure is internally divided with shrouds to maximize operator safety by isolating the toxic areas from the normal working areas. The plan layout of the enclosure showing the shrouded areas is depicted on Figure 2, "MPF Site Layout".

Automatic process controls are provided for efficient operation of the equipment. The mechanical equipment will be interlocked with redundant sensors to maximize safety and to meet the current requirements for human factors engineering.

Energy conservation measures were worked into the final concept design. Conservation methods adopted in this design include:

Increased use of thermal insulation.
Reduced air infiltration in the furnace system.
Minimization of combustion air flow.
Use of a variable throat venturi scrubber.
Closed loop boiler condensate return.
Separation of the combustion air flow using both fans and blowers.
Use of capacitors on electric motors for improved power factor.
Energy saving enclosure lighting by using fluorescent lighting.

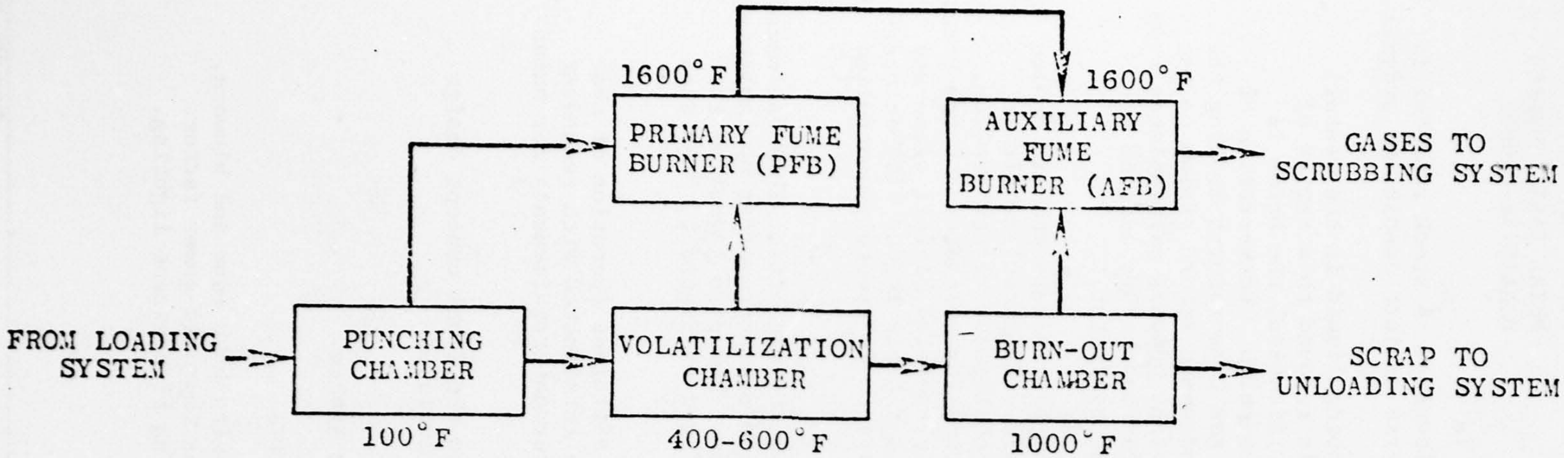

Figure 3. Schematic of Furnace System for Metal Parts Furnace and Air Pollution Control System

I. SCOPE

The final concept design encompasses a complete Metal Parts Furnace processing system. This system includes a direct fired continuous three (3) chamber roller hearth furnace, a primary fume burner, an auxiliary fume burner, a gas quench unit, a venturi scrubber, a chemical scrubber with a demister section, liquid treatment and salt drying equipment, burster well scrap handling facilities, PDR trolley projectile interface with a multi-position projectile loader, BIF item handling equipment, scrap handling and cooling equipment, utility auxiliaries, enclosure with internal shrouds and site facilities including floors and foundations.

Electrical controls, power distribution and motors are included. A nominal 150 kw diesel electric emergency power set is included. Automatic interlock and process controls are included as required to provide for automatic operation of the equipment.

Process controls will be modularized and panel mounted for installation in the Government furnished control module. The space allocated in the Government Control Module will not be adequate to house the necessary process controls and the required recorders. Provision for additional space will be provided adjacent to the furnace and within the enclosure. Operator control stations, including control rooms, will be provided both at the charge end and the discharge ends of the processing facility.

A complete set of work trays and fixtures are included to suit all of the munition configurations specified in the CAMDS Munitions Matrix.

Preparation of a level and clear construction site will be Contractor furnished. Utilities will be brought to Government specified interface points. Equipment and enclosure foundations, sumps and floors will be Contractor furnished.

Ventilation fans and activated carbon filters for the shrouded internal ventilated areas will be Government furnished. Contractor will design and install ductwork to the filter inlet flanges.

II. GENERAL REQUIREMENTS

A. Capacity

Processing rates for munitions and agents will be as set forth on the CAMDS Munitions Matrix, Drawing sheet L-38, for the Metal Parts Furnace.

B. Life Expectancy

Life expectancy for components used in the system will vary according to chemical corrosion, thermal spalling and mechanical abrasion actions developed in the operation of the equipment. The general philosophy used in the design of thermal processing equipment for life expectancies is set forth as follows:

1. Alloy work trays and fixtures . . . 1.5 years

2. Alloy furnace parts . . . . 3.0 years

3. Refractories . . . . 5.0 years

4. Corrosion resistant linings . . . . 2.0 years

5. Mechanical components . . . . 10,000 hours (minimum)

Detailed development of the life expectancy for all component categories subject to a finite useful life has been explored in this final design. Chemical corrosion rates for metals have not been completely piloted at the time of this report. The data used in preparing equipment specifications included in this report resulted from Mustard piloting tests, a GB demil operation's report and from experience gained in conducting this project.

C. Transportability

Component subassemblies will be designed with ultimate transportability in mind. The furnace will be modularized and flanged for easy disassembly and reassembly.

Detailed definition of the transportability features are discussed in the System Specifications (Data Item A001) and are shown on the Final Concept Design Drawings (Data Item A003). Subassemblies and auxiliary components will be skid mounted whenever possible to enhance their transportability. Subassemblies will be designed specifically not to exceed the following dimensional and weight characteristics:

Length: 40 ft
Width: 10 ft
Height: 11 ft
Gross Weight: 40 tons

D. Ambient Conditions

The equipment is designed for installation at a nominal 5000 ft elevation above sea level. Ambient temperatures ranging from -10 F to 110 F are accounted for in the equipment design.

E. Scale-Up

The eventual need for scale up to processing rates in the order of five times the CAMDS requirement have been addressed in the concept design study. The furnace can be scaled up by building in a double width. With increased firepower, we calculate that a double row roller hearth furnace can be built to provide a production factor of 2.5 on filled ton containers and 2.0 on filled projectiles. A multiplicity of two (2) furnaces would provide a scale up of 5.0 on ton containers while using common charging and discharging scrap handling facilities.

Air pollution control equipment can be readily scaled up either with larger units or a multiplicity of units.

III. PROCESS REQUIREMENTS

A. Certification

The equipment will be used to thermally detoxify both filled and drained munition items. Scrap metal parts will be thermally treated at a nominal 1000 to 1200 F for thermal certification of the detoxification. Detoxification residence time and temperature for each tray load will be recorded on a strip chart recorder coupled to a temperature sensing thermocouple located in the burn-out chamber.

Flue gases will be treated with a NaOH caustic solution to neutralize all acid products. Agent traces will be thermally destroyed in the fume burners provided for that purpose, using a nominal 1600 F and a total residence time of 1.0 seconds to complete the detoxification process. Temperatures for both the primary fume burner (PFB) and the auxiliary fume burner (AFB) will be recorded on a strip chart temperature recorder. The pH of the caustic scrubbing liquor will be monitored and controlled continuously and recorded on a strip chart recorder.

Salts from the scrubbing process will be stored as a brine for four (4) hours for chemical certification by Government QA personnel.

B. Emission Standards

All of the following emission standards shall be met:

1. Air Quality

The current air quality standards for stack emissions are as follows:

Emission	Standard
SO_x (Note: SO_x includes SO_2, SO_3, and other forms of oxidizable sulfur)	500 ppm (as SO_2) or 80% removal of input sulfur, whichever is more stringent
Particulates	$E = 3.59\ P^{.62}$ where E = allowable emission rate, lb/hr P = weight of material (combustible and noncombustible) excluding gas and liquid fuel, introduced, tons/hr
Visible Opacity	20% or less. This standard is interpreted to mean that no air contaminant will be emitted which is of such a shade or density as to obscure an observers' vision to a degree in excess of 20 percent. An air contaminant is defined as any fume, smoke, particulate matter, vapor, gas, or any combination thereof, but not including water vapor or steam condensate.
Agent Mustard	0.03 mg/am^3 (1 hr average)
Agent GB	3×10^{-4} mg/am^3 (2 hr average)
Agent VX	3×10^{-5} mg/am^3 (2 hr average)

2. System Liquids

Prior to the drying or bulk reduction of liquid streams, agent concentrations within these streams shall not exceed the following limits:

Agent	Standard
Mustard	2 ppm
GB	5×10^{-8} gram/ml (enzyme test)
VX	5×10^{-8} gram/ml (enzyme test)

3. Dryer Effluent Air Quality Standards

The particulate emissions from the dryer shall be controlled so as not to exceed limits based on Colorado Air Quality Control Regulations No. 1 (adopted 71 DEC 09) as applicable to manufacturing processes; typical allowable emission rates are contained in the following table:

Proc Wt Rate ** lb/hr	Emission Rate lb/hr
50	.3
100	.55
500	1.53
1000	2.25
5000	6.34
10000	9.73

**Wt of feed stock

4. Water Quality

No liquid effluents shall leave the system. All liquid streams shall be dried and solid residues recovered. Thus, no water quality standards shall be applicable.

5. Additional Emission Limits

The Contractor shall also design the system, to the limit of the current state-of-the-art to meet the following stack emissions. These represent design goals and are not considered air quality standards. The final unit is designed to not exceed the following limits:

Emission	Standard
Inorganic phosphate as H_3PO_4	0.14 lbs/min
Inorganic fluorides as HF	0.007 lbs/min
Total acidity as HCL	0.03 lbs/min

IV. EQUIPMENT DESCRIPTION AND METHOD OF OPERATION

A. Material Handling

1. Trays and Fixtures

As outlined in the "Concept Design Summary" section the basic material handling element is a modularized work tray which serves as a common carrier for munitions, bulk items and scrap parts. The basic tray module is a 2'-0" long x 3'-0" wide alloy casting. Four of these modules are assembled together to form an 8'-0" long x 3'-0" wide work tray as shown on drawing, L-44.

Each set of trays will include fifteen (15) 8'-0" long tray units. We recommend that the furnace be purchased with two (2) sets of trays.

Normal disposition of the trays in a set will be as described below:

Charge end ------------	2
Furnace ---------------	3
Discharge end ---------	1
Cooling stations ------	2
Return conveyor -------	3
Spares ----------------	4
	15

Fixtures will be designed for the following munition categories:

a. 105 mm and 4.2" mortar projectiles.

b. 155 mm projectiles.

c. 8" projectiles.

d. MC-1 bomb.

e. MK-94 bomb.

f. Spray tank.

g. Ton container

h. Basket container for bursters, fuses, etc.

Sufficient fixtures in each category will be included to outfit two (2) complete sets of trays.

2. Multi-Position Loader (MPL)

The multi-position loader is located at the end of the Government supplied conveyor from the PDR. The MPL will be capable of automatically loading projectiles as shown on drawing L-23. The MPL will consist of a structural steel base located at ground level. On top of this base will be a rigid frame (#1) with V-wheels. This rigid frame #1 will be powered by two (2) Saginaw screws. Setting on top of rigid frame #1 will be another rigid frame (#2) with V-wheels transversing the V-wheels of rigid frame #1. Frame #2 will also be powered by a Saginaw screw: On top of frame #2 will be a series of power driven rollers complete with limit switches, chains, reducer and motor. Clamps will be provided to position the tray for its initial loading. The Government supplied conveyor and projectile release mechanism will be required to deposit a projectile in the same given spot within 1" of its diameter. Therefore, the center of the projectile base is to be within 1/2" of the center. To receive these projectiles from the conveyor will be a specially designed "egg-crate" fixture positioned on a 3'-0 x 8'-0 cast articulated type tray.

Each rigid frame will be powered by DC drive complete with tachometer, and reducer. DC drives to be static state. The drive system is mounted on its own particular rigid frame. Remotely located will be a programmable controller and operator station. The programmable controller will be of the tape type-system that will allow for different types of loading patterns by changing the tape.

Upon receiving a signal from the PDR conveyor that a projectile is in a position to be lowered into the "egg-crate" fixture, the operator would then position a tray and fixture from the transfer car to the MPL and secure its position by means of the clamps. The operator would then release the projectile from the Government conveyor into the first position as indicated on drawing L-45. When the reclose is complete, the MPL will automatically index to position two. The operator can now visually see if this motion has transpired and is now ready to release another projectile from the Government conveyor when it arrives.

For 155 mm projectiles the operator would repeat this sequence 44 times. After the tray is fully loaded the operator would start the drive on the MPL and would sequence it to the transfer car.

3. Bulk Item Transfer and Loading

a. General Description

Bulk items will enter the furnace loading area via the Contractor furnished tray return roller conveyor. A Government furnished fork lift truck with boom attachment will be used to move the GB and VX processed items from the BIF holding area to the roller conveyor. (In the case of the Mustard filled ton containers, these will be transferred directly from the transport truck to the roller conveyor with the same fork lift/boom combination).

The bulk items will be placed on the Contractor furnished tray located on the roller conveyor immediately adjacent to the conveyor airlock outer door. Upon placement of the bulk item onto the tray, the outer door is opened and the tray/bulk item is transferred into the conveyor airlock, the outer door is closed, the inner door opened and the tray/bulk item is transferred onto the charge car. The purpose of the roller conveyor airlock is to isolate the "clean" side of the conveyor from the "contaminated" furnace loading area.

The Government furnished fork lift/boom combination will be equipped with an appropriate sling device to handle the bulk item being processed.

b. Method of Operation

The sequence of operation for loading is as follows:

1) The fork lift truck with boom and sling attached is driven to the exit door located at the south end of the BIF holding area.

2) The BIF operator opens this door and the boom is permitted to extend through the door opening so that the boom hook and sling are directly over the bulk item resting on a stationary cradle/skid inside the holding area.

3) The BIF operator engages the sling hooks into the bulk item lift points.

4) The fork lift operator lifts the bulk item from its cradle and transfers same to a door in the east side of the MPF enclosure.

5) The BIF operator closes the BIF exit door and follows the fork lift to the MPF enclosure door.

6) At this point, the BIF operator opens the MPF enclosure door and the fork lift operator deposits the bulk item onto a tray resting on the roller conveyor.

7) After ensuring proper position of the bulk item on the tray, the BIF operator disengages the sling hooks from the bulk item and the fork lift is backed away from the opening and the door is closed by the BIF operator.

8) The furnace MHE operator opens the tray return airlock outer door, remotely, and runs the conveyor to move the bulk item-loaded tray into the airlock.

9) The tray airlock outer door closes, the inner door opens and the loaded tray is rolled onto the furnace charge car. The inner airlock door is closed. All operations are accomplished by remote control.

10) The furnace charge operator then transfers the loaded charge car, by remote control and visual contact, to the front of the furnace for charging.

11) After charging the furnace, the charge car is returned to the normal position, in line with the return tray conveyor, in readiness for the next cycle.

c. Components

Components will include Government furnished fork lift truck with boom and sling and Contractor furnished bulk item tray, tray return conveyor with airlock, charge car, remote control panel and TV camera/monitor to observe remotely controlled conveyor transfer sequences through the conveyor airlock.

4. Burster Well Loading

a. General Description

Burster wells removed from projectiles will be loaded into containerized (basket) trays using the same basic tray modules as the projectiles and the bulk containers. The basket-tray combinations are transported and charged to the furnace in the normal manner. The types of burster wells to be processed are shown in Table 1, "Burster Well Matrix".

b. Method of Operation

The burster wells will be transported to the MPL interface on the same trolley conveyor as the projectiles. The burster wells will be discharged from the trolley into a waiting basket located at the burster well basket loading station near the multi-position loader. The basket-tray combination is supported on a power driven roller conveyor disposed for transfer of the basket-trays to a furnace charging car. This arrangement is shown on Drawing L-27.

The basket-trays loaded with burster wells will be processed through the MPF at the end of the normal twenty (20) hour working day.

5. Charge Car

a. General Description

The general arrangement of the charge car is shown on Drawing L-46. The car is mounted on power driven wheels which ride on rails located in the floor. Movement of the car over the rails enables the charge car to move transversely. A power driven, roller table conveyor is located on top of the charge car enabling transfer of the heavy trays into the furnace.

b. Method of Operation

The loaded trays are transported between the tray loading stations and the furnace centerline by the charge car described above. The car motion is remotely controlled from the MHE Control Panel. A cable reel is furnished to retract and coil the power cables.

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TABLE 1

BURSTER WELL MATRIX

	Size	Burster	Wt.	Ln.	Dia.	Rate/hr	lbs/hr	Packed Vol.	Loose Volx2	Ft^3/hr	*Approx. Baskets /day
Cartridge M360	105	M16	2.2	13	1.87	60	132	0.013	0.026	1.58	0.52
Projectile M121A1	155	M15	5.4	20	2 1/4	40	216	0.026	0.052	2.08	0.69
Projectile M122	155	M15	5.4	20	2 1/4	40	216	0.026	0.052	2.08	0.69
**Projectile M426	8"	M161	11.2	27	3 1/8	24	269	0.15	0.3	7.3	2.4
Cartridge M60	105	M5	1.48	12.52"	1.005	60					
Cartridge M2/M2A1	4.2	M14	0.7	15	1	60	~	0.008	0.017	1.04	0.34
Projectile M110	155	M1	2.0	20	1 1/4	40	80	0.014	0.029	1.16	0.39
Projectile M104	155	M1	2.0	20	1 1/4	40	80	0.014	0.029	1.16	0.39

* Burster well basket volume = 60 ft^3

** Drained VX and GB Munitions only

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6. Furnace Conveyor

a. General Description

The Metal Parts Furnace is a zoned, continuous furnace including:

1) An uninsulated punching chamber equipped for bulk container twin punch operation.

2) A volatilization chamber designed for operation over a 500-1000 F range.

3) A burn-out chamber designed for operation at 1000-1100 F range and equipped with means for automatic air sparging of ton containers.

Each furnace chamber is equipped with power driven, tray conveying rollers. The drives for each chamber can be operated independently. The furnace is provided with tightly fitting, dry type charge and discharge doors. Automatically actuated doors are also provided between the furnace chambers.

Positive positioning of the work trays is achieved by means of mechanical flag switches which stop the work trays in the exact position required for a particular process operation.

The general arrangement of these mechanical features is shown in Drawings L-2 and L-29.

b. Method of Operation

Assuming both furnace chambers fully loaded and a load on the charge table and in the punching chamber, the method of operation is as follows:

1) The burn-out chamber discharge door opens responsive to an operator signal. Interlocks prevent premature opening.

2) The loaded tray in the burn-out chamber is transported by the fast speed roller drive to the air cooling chamber transfer position.

3) The burn-out chamber discharge door closes and the volatilization chamber discharge door opens responsive to a limit switch signal.

4) A loaded tray moves from the volatilization chamber position to the burn-out chamber position established by depression of a flag switch. The volatilization chamber roller drive is actuated by limit switch contact indicating that the discharge door is in the raised position.

5) The volatilization chamber discharge door is closed responsive to the actuation of the tray position flag switch in the burn-out chamber, and the volatilization chamber door opens responsive to a limit switch signal that the discharge door is in the closed position.

6) When the volatilization chamber charge door is in the raised position, a limit switch signal actuates the punching chamber and the volatilization chamber roller drives moving a loaded tray from the punching chamber into the volatilization chamber to a position established by actuation of a flag switch.

7) The volatilization chamber charge door is closed responsive to the actuation of the tray position flag switch, and the punching chamber outer door opens responsive to a limit switch signal that the volatilization chamber charge door is in the closed position.

8) Projectiles are handled without punching. The punching chamber serves as a vestibule only in this case.

9) When a limit switch indicates that the punching chamber outer door is in the raised position, the charge table and punching chamber roller drives are actuated to move a loaded tray to a station beneath the ton container punches established by depression of a flag switch.

10) The punching chamber flag switch actuation signal then closes the punching chamber outer door. Operator actuates the punch sequence.

11) The anvil rises and actuates a limit switch, the punching occurs, limit switches are tripped to indicate that punch stroked and returned to its clear position.

7. Discharge Car

For unloading the furnace and for lateral transfer to cooling and unloading stations, a discharge car is provided. This car

is floor mounted on flanged wheels which ride on rails located on the floor. Movement of the car, rolling on the rails, enables the transverse movement of trays in front of the stations. Trays are moved horizontally, into and out of the stations with the roller table conveyor on top of the charge car. The roller table is powered for movement of the heavy trays. The car motion is remotely controlled from the Scrap Handling Control Panel. A cable reel is provided to coil and retract the power cables.

8. Air Cooling Chambers and Scrap Metal Handling

a. Air Cooling Chambers

Located within the enclosure and adjacent to the furnace discharge car transverse track. Two (2) air cooling chambers are included for cooling the scrap metal parts. The scrap metal parts will be removed from the furnace burn-out chamber and transferred to one of the cooling chambers. The transfer car is remotely controlled for maximum operator safety.

Each cooling chamber will have sheet metal ductwork to direct fresh air in from outside the enclosure. Exhaust air is ducted through the enclosure to exhaust vents located external to the enclosure. The cooling chambers are completely enclosed with a steel shroud to direct the cooling air flow. Each chamber will have a remotely operated vertical rising door to minimize entrainment of air from within the enclosure.

Electrical interlocks will include:

1) Fan operating contact, prevents use of chamber without fan operating.

2) Tray position limit switch, denotes tray in chamber.

3) Door down position limit switch, prevents charging or discharging with door closed.

4) Door up position limit switch, actuates signal lamp to show operator of abnormal operating position.

b. Bulk Item Scrap

Scrap from bulk item processing will be conveyed on trays using the discharge car to shuttle the trays to an off-loading roller conveyor located in the receiving and unloading area. This area is serviced by a rail crane and hoist.

Transfer of the bulk items from trays to waiting empty truck will be accomplished by manual manipulation of the rail crane and hoist controls. The hoist will be equipped with either an electromagnet or a hooking arrangement, designed to adapt to the various bulk items.

c. Projectile Scrap

Scrap projectiles will be lifted from the trays using an electromagnet, an electric hoist and a rail crane. The electric hoist will have remote controls for manual operation of the equipment.

The operator will load the scrap projectiles directly into waiting empty trucks.

d. Scrap Parts

Scrap parts in containerized trays will be offloaded by dumping the trays using the rail crane and hoist located in the unloading area. The trays can be dumped directly into the Government furnished scrap truck.

9. Return Conveyor

A roller table, tray return conveyor is provided for conveying trays from the scrap handling area back to the charge end of the furnace. The roller table conveyor is designed to accommodate the standard 3'-0 wide trays and is equipped with powered rollers. As previously described the tray return conveyor is used for loading bulk items onto trays in a "clean" area external to the charge end conveyor airlock.

10. Monitoring Materials Handling Operations

Remote TV cameras will be provided for visual monitoring of critical MHE transfer operations. The places to be monitored will include:

a. MPL long axis, projectile loading point

b. MPL cross axis, projectile loading point

c. Scrap loading point

d. Charge car

e. Punching chamber

f. Discharge car

g. BIF loading point

B. Metal Parts Furnace

1. General Description

The Metal Parts Furnace is designed to thermally detoxify filled and drained munitions and containers to provide for certification of the effluents including flue gases, metal parts and salts.

The furnace design is based on the concept of controlled volatilization requiring the heating operation to take place in an essentially oxygen-free atmosphere with the vaporization and combustion of agent vapor in physically separated chambers.

This concept was successfully demonstrated using a ton container furnace at Rocky Mountain Arsenal (CAMDS Metal Parts Furnace, Pilot Test Results, Heavy HD Ton Containers MFF-P-HD-RMA-2-1 Report dated 1 May, 1974).

The furnace design must be capable of handling and treating projectiles from the punch, drain and rinse equipment (PDR) and agent containers from the bulk item facility (BIF). The list of components for processing in the Metal Parts Furnace is shown in the "Munitions Matrix" Drawing L-38. Dimensions of these components are as shown on Table 2, "Munitions Configurations".

TABLE 2

MUNITIONS CONFIGURATIONS

No.	Munition	Length	Diameter	Metal Weight	Rate
1	M360 105 mm	15.7"	4.223"	27.7 lbs	60/hr
2	M121A1 155 mm	22.84"	6.22"	79.7 lbs	40/hr
3	M122 155 mm	22.84"	6.22"	79.7 lbs	40/hr
4	M426 8"	29.05"	8.284"	153.8 lbs	24/hr
5	M60 105 mm	15.79"	4.223"	31.8 lbs	60/hr
6	M2/M2A1 4.2"	16.01"	4.2"	12.0 lbs	60/hr
7	M110 155 mm	23.8"	6.22"	80.0 lbs	40/hr
8	M104 155 mm	23.8"	6.22"	74.0 lbs	40/hr
9	MC1 Bomb	51.4"	17"	435.0 lbs	2/hr
10	MK94 Bomb	60"*	10.75"	278.0 lbs	1/hr
11	Spray Tank	136" (excluding tail)	22.5"	500.0 lbs	0.25/hr
12	Ton Container	81.5"	30"	1600.0 lbs	0.25/hr

*Dimension scaled from drawing.

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The Metal Parts Furnace will be made up of three zones: an uninsulated punching chamber, a refractory lined heating chamber for controlled volatilization of agent, and a second refractory lined heating chamber for final burnout of agent. The furnace chambers will be separated by vertical lift inner doors. The work pieces are supported on alloy trays equipped with suitable fixtures. The trays are conveyed through the furnace by power driven rollers.

The heating zones of the furnace will be provided with air atomizing oil burners arranged to give direct impingement of steam diluted combustion products on the side of the bulk containers (ton containers and spray tanks). Sufficient steam will be used to give tempered flame operation and minimize development of hot spots on the container walls. The burners will operate at a slightly rich, controlled air/fuel ratio to prevent introduction of oxygen into the furnace. The excess water vapor introduced will be removed in the quench scrubber and will not significantly add to the load on the air pollution control equipment. Auxiliary controlled air/fuel ratio burners will be provided above and below the work level for heating tray loads of projectiles.

a. Punching Chamber

The punching chamber is a gas-tight uninsulated metal housing surrounding the bulk container punching station. It is equipped with power-driven rollers to convey the loaded work trays to a fixed position beneath the punches determined by the tray tripping a flag switch located between conveying rollers. The entry end of the punching chamber contains a hydraulically actuated, vertical lift door which is electrically interlocked with other system components as previously described. The discharge end is flanged for modular transportability of this part of the furnace assembly. The punching chamber is vented by a duct leading to the PFB and is ventilated as required.

b. Punch System

The purpose of the punch system is to provide openings at each end of the ton containers for release of agent vapors without internal pressure buildup during the volatilization period. The punch system consists of the two hydraulically actuated punches passing through seals in the roof of the furnace with correspondingly located anvils beneath the support tray which elevates the load support tray to a position above the conveyor rolls and provides support to the punch section of the bulk container during the punching operation. The design of the punches and the corresponding punch control circuits will be very similar to the system now in satisfactory operation at RMA.

c. Furnace Components

1) Casing

The furnace casing will be fabricated of steel plates, bound together by outside structural steel buckstays. The casing will include a reinforced structural steel bottom plate extending the full length of each modular transportable section. A steel top plate will be provided and the entire casing will be seam welded to prevent air infiltration. Each furnace section will be provided with flanged joints for modular transportability.

2) Lining and Insulation

Both the volatilization chamber and the burn-out chamber will be lined with 9" of 2300 F insulating firebrick.

3) Furnace Doors

The entry door to the punching chamber will be constructed of metal and provided with lock devices to insure tight sealing against leakage of agent vapor. The inner surface of this door will be epoxy coated.

The door at the discharge end of the burn-out chamber will be of a refractory lined type with a steel casing on the outside surface provided with anchor clips to hold the refractory in place. This door will also be provided with locking devices to prevent agent vapor leakage.

The doors between the punching chamber and the volatilization chamber and the volatilization chamber and the burn-out chamber will also be refractory lined with an alloy support panel on one side provided with anchor clips to hold the refractory securely in place. All doors will be the hydraulically operated vertical lift type.

4) Roller Hearth Conveyor

The work pieces (bulk containers, munitions, scrap parts) loaded on fixtured, articulated support trays will be carried through the furnace on power driven rollers extending through the side walls of the furnace, and mounted in flange ball bearings of the self-aligning type. These bearings will be bolted to adapters, which will be bolted to the furnace casing.

All the rollers within the punching chamber and furnace chambers will be made of corrosion-resistant alloy and, in the case of the furnace chambers, heat- and corrosion-resistant alloy will be used.

The rolls will have aluminized alloy trunnions welded to the alloy roll barrel to make a suitable connection for alloy operating in a rich hydrocarbon atmosphere. Aluminizing the roll trunnions prevents carbon attack on the trunnions in the colder wall area.

Each roll will be provided with a sprocket attached on one end. The sprockets will be chain-driven roll-to-roll.

5) Bearings and Seals

Bearings will be flanged pillow block ball type, anti-friction with external lubrication. Each bearing will be bolted to finned adapters for cooling.

The bearings should be purged with dry air to prevent condensation of acid gases contained within the furnace volatilization and burn-out chambers. The air will be Government furnished.

6) Conveyor Drive

The main furnace conveyor drive will be a single speed, rapid movement for transferring work from the charge car into the furnace chambers. This drive will have a 1 hp, 1200 rpm Westinghouse MAC, TE.FC. electric motor complete with speed reduction unit, shafting, sprockets, clutches and structural support base.

Electric clutches are provided to isolate the various furnace chambers to permit operator manipulation for startup, shutdown and interim processing.

7) Burner Equipment

Both the volatilization chamber and the burn-out chamber will be provided with air atomizing distillate oil burners. The general firing arrangement will be above and below the roller conveyor and loaded work support tray. The firing pattern will produce a circulatory movement of combustion products around the conveyor and loaded trays producing the maximum degree of temperature uniformity in the load and a high rate of heat transfer from the combustion products to the surrounding refractory surfaces.

The volatilization chamber will also be equipped with air-atomizing distillate oil burners located opposite the horizontal centerline of a ton container on the work support tray. These burners will be located in pairs on each side of the furnace with dilution steam jets centered between each pair of burners. These burners will give direct impingement on the ton container and the steam jet will mix with the combustion products on the impingement surface and reduce the tendency toward development of hot spots at impingement points. In addition, five (5) chamber volumes of steam will be injected to assist in rapid purging of the volatilization chamber after charging to reduce the oxygen concentration resulting from any air infiltration and to reduce the Mustard volatilization rate very rapidly if a sudden excursion in PFB flue gas temperature should occur.

8) Combustion and Sparging Air

Both primary and secondary air will be provided from centrifugal blowers with capacity and pressure ratings suitably corrected for local barometric conditions. Direct connected 3500 rpm blowers will be used to take advantage of the flywheel effect during transfer to emergency power.

Sparging air will be provided from a 60 psig compressor.

9) Sight Ports

Two (2) sight ports will be provided for each furnace chamber for viewing internal furnace operation.

10) Hydraulic Unit

The furnace will have a pressure hydraulic pump unit with reservoir tank, tank magnets, filters, gauges, flow control valves, 4-way solenoid valves and oil cooler for automatic operation of the punch, anvil and furnace door cylinders. All hydraulic cylinders will be complete with speed control in both directions.

Sound level attenuation will be provided to meet the requirements for 85 DB noise levels for continuous operation.

2. Method of Operation

a. Ton Containers

1) Volatilization Chamber

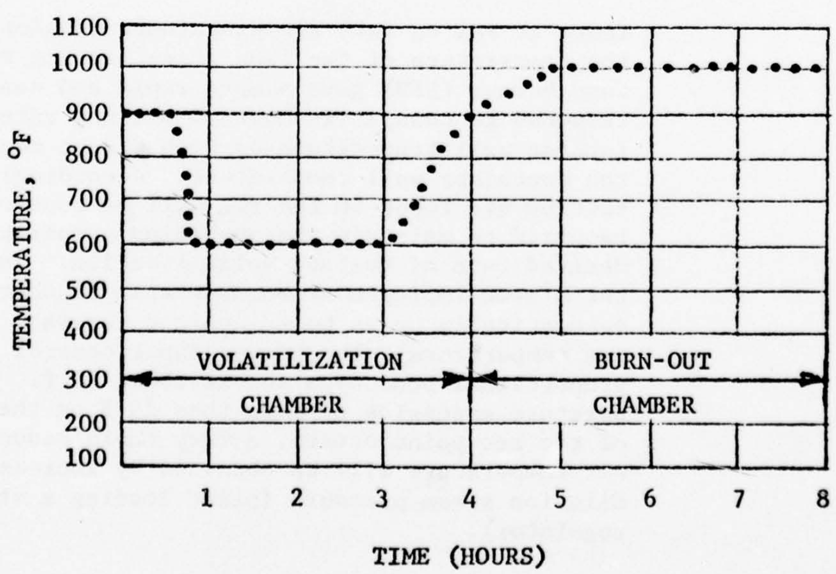
The volatilization chamber is equipped with two sets of controlled air/fuel ratio burners, one consisting of conventional over- and under-firing burners for control of chamber wall temperature during heatup and a second set located opposite the centerline of ton containers for impingement heating during both the heatup and controlled vaporization periods. At the start of the heating period the chamber wall temperature is maintained at about 900 F by a differential head controller (DHC). Midway through the heatup period the DHC drops the wall temperature to 600 F and maintains this temperature until the heatup is completed (1 hour). A temperature rise of about 100 F of the product stream from the primary fume burner (PFB) indicates that Mustard vaporization has commenced and when this signal has been received the over- and under-fired burners are automatically shut off and input for heat losses and Mustard evaporation is provided by the controlled ratio, direct impingement burners.

Tests at RMA on full ton containers disclosed that the temperature of the flue gases leaving the primary fume burner (PFB) gave a more rapid and sensitive response to changes in Mustard boiling rate than furnace wall temperature or even direct measurement of ton container wall temperature. Accordingly, the combustion air input to the PFB will be controlled as required to maintain the operating temperature at the desired rate of Mustard volatilization. The input to the direct impingement burners will be controlled automatically so as to maintain a constant PFB flue gas temperature. The burner input control will be the proportional band type set at about 25 F. If a temperature excessive of more than 25 F on the high side of the set point occurs, a very rapid reduction to the set temperature will be obtained by increasing the dilution steam pressure (pilot loading a steam pressure regulator).

The fuel input to the volatilization chamber will be controlled to maintain a constant temperature of 1600 F in the PFB when the PFB is supplied with its rated combustion air. As the residual Mustard agent in the ton container decreases, the temperature in the volatilization will increase to maintain the desired volatilization rate. The volatilization chamber temperature will reach its upper limit of 900 F but the Mustard volatilization rate will start to decrease as the residual Mustard is consumed. At this point, the combustion air to the PFB starts decreasing to maintain 1600 F in the PFB. When the PFB combustion air reaches its minimum, the volatilization will be complete so an interlock will be made, and the ton container can be moved to the burn-out chamber. A fresh ton container can then be moved into the volatilization chamber. The volatilization chamber will already be at 900 F when the fresh ton container is charged.

The time-temperature profile for the total heating process is shown schematically on Figure 3.

FIGURE 3 Time-Temperature Chart, Ton Containers



2) Burn-out Chamber

The burn-out chamber temperature will be maintained at a constant setting of 1000 F or higher if needed. The load temperature should reach the set point very rapidly because of the small temperature rise needed (100 F). For ton container charges, bayonet type sparging air lances will be lowered automatically to the punched openings and sparging air will then be introduced into the container to complete the burn-out of solid carbon or sulfur or gases trapped beneath scale pockets. This procedure will prevent or minimize the afterburning previously observed after the bulk container has been removed from the furnace. Sparging will take place during the final 50% of the burn-out cycle.

After removal from the burn-out chamber the thermally detoxified load is transferred to an air cooling chamber (described elsewhere in this report).

b. Mustard Filled Projectiles

1) Volatilization Chamber

Detoxification of Mustard filled 155 mm projectiles at a 40/hour rate represents the heaviest furnace loading both in heat load requirement and total amount of Mustard evaporation on an hourly rate basis.

	Lbs/Hr
Steel	3200
Mustard	468

Each tray load of 155 mm projectiles will contain 44 projectiles so that the cycle time will be 66 minutes to obtain the specified production rate. Allowing time for sequential door operations and a 15 minute heat-up time in the volatilization chamber the rates of Mustard vaporization required to meet design criteria are:

Condition	Lbs/Hr
Volatilization process rate	690
50% Allowance for peak rate	1035
25% Design safety factor	1294

Theoretical heat transfer calculations show that a volatilization chamber temperature of 1000 F will be required to heat the filled projectile tray load to the volatilization temperature in the 15 minute heat-up period. During the heat-up period both the over- and under-fired controlled ratio burners and the controlled ratio impingement burners will be firing. Use of the impingement burners will assist in spreading the period of Mustard evaporation over a longer time because the outer row of projectiles and particularly those projectiles directly in the path of the combustion products will heat up more rapidly and start volatilizing Mustard before the projectiles in the center rows.

As in the case of the filled ton containers, the DHC controller will decrease the volatilization chamber wall temperature to about 700 F just before the end of the heating period. Because of the limited time available for temperature changes, use of a large amount of excess dilution steam will probably be required.

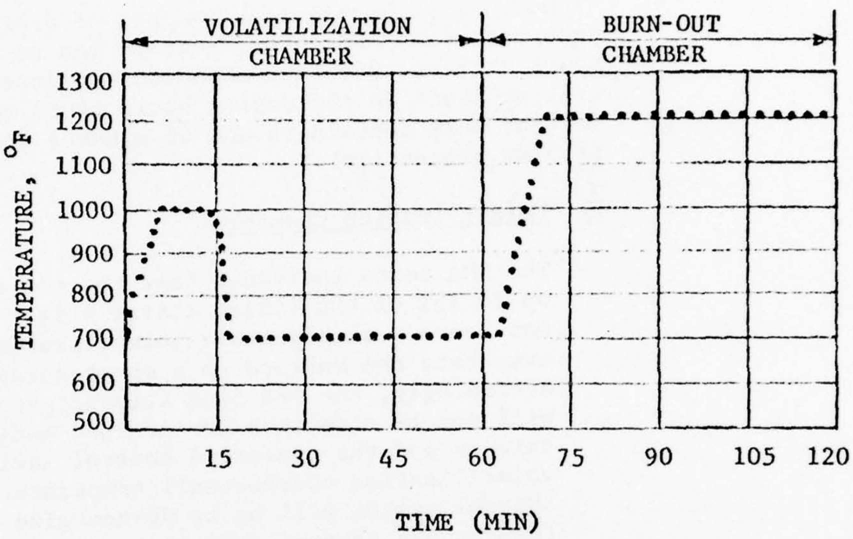
When a 100 F increase in PFB flue temperature indicates that volatilization has commenced, the burner input will be controlled so as to maintain the PFB flue temperature constant at 1600 F with the combustion air input to the PFB held constant at that level required to maintain 1600 F PFB flue gas temperature at the desired rate of Mustard volatilization.

Because of the short heat-up and volatilization times and the hazard involved in operating the PFB and AFB systems on an average rate basis so close to the peak Mustard incineration design rate, it is doubtful that Mustard evaporation can be completed in the volatilization chamber. It may be necessary to complete as much as 15% to 20% of the Mustard volatilization in the burn-out chamber.

The necessity for volatilizing at 700 F until the end of the cycle period means that the volatilization chamber wall temperature will not be increased to 1000 F until the start of the next heating cycle.

The time-temperature profile for the total heating process for filled projectiles is shown schematically in Figure 4.

FIGURE 4 Time-Temperature Chart, Projectiles



2) Burn-out Chamber

If Mustard is completely evaporated in the volatilization chamber, the burn-out chamber wall temperature will be maintained at 1200 F to heat the projectiles from 700 to 1000 F in the allowed 66 minute cycle period. This situation is shown in Figure 4 above.

If 15% to 20% residual Mustard remains in the projectiles, it will be consumed in the burn-out chamber. This chamber will be controlled at 1000 F since the quantity of residual is small enough that controlled volatilization will not be necessary.

c. Drained Munitions and Bulk Containers

The only cases to be considered for this type operation will be the munitions and containers drained of GB and VX down to a maximum of 5% of the filled content. All of the

Mustard agent munitions and containers will be processed in the filled state.

Although the thermal requirements of drained loads are such that complete detoxification can be achieved in 2 hours or less, the thermal operations described herein will be based on the design basis cycle times of 4 hours for the bulk containers and 66 minutes for the munitions (155 mm projectile).

1) <u>Volatilization Chamber</u>

The RMA tests indicated that the ton containers with up to 15% of the filled charge weight of Mustard do not reach a steady state volatilization condition but evaporate the Mustard as a short duration pulse. Accordingly, the PFB flue temperature control mode will not be effective for drained munitions and containers and the preferred control variable is the volatilization chamber wall temperature. The simplest control system will be to de-energize the PFB flue temperature control switching contact and maintain the volatilization chamber wall temperature at a constant 900 F for drained projectile loads and at a constant 600 F for the drained container loads. Only the over- and under-fired controlled ratio burners will be required for the bulk containers. Because of the heavier steel load for the drained projectile case and the 66 minute cycle time required, both sets of controlled ratio burners may be needed to obtain complete volatilization in the allowed cycle period. Completion of volatilization in the burn-out chamber will not be acceptable for GB and VX because the extermely low tolerance level requires that incineration take place in both the primary and auxiliary fume burners. The flue products from the burn-out chamber are vented directly to the auxiliary fume burner.

2) <u>Burn-out Chamber</u>

As in the case of filled containers, the burn-out chamber will be maintained at a constant temperature of 1000-1100 F.

The furnace chamber temperatures and time temperature relationships presented in this report are derived from theoretical calculations and will be adjusted as

required on the basis of field tests performed on the controlled volatilization production furnace installation during the shakedown and preliminary trial period.

C. Fume Burners

Flue gases from both the punching chamber and the volatilization chamber flow to a primary fume burner (PFB). Flue gases from the PFB and the burn-out chamber are ducted to an auxiliary fume burner (AFB) for final afterburning at a nominal temperature of 1600 F. Residence minimum time in each fume burner is 0.5 seconds giving a residence time for the bulk of the Mustard fumes of 1.0 seconds. The minimum total residence time for the VX and GB fumes will be 2.6 seconds at 1600 F.

1. Primary Fume Burner (PFB)

a. General Description

Agent fumes from the punching chamber and the volatilization chamber will be incinerated in an oil fired, horizontal, fume incinerator. This fume incinerator will be designed to resemble the patented Surface Combustion "Rich Fume Incinerator" having oil burners firing into a hot track as an ignition source, and a means to mix the auxiliary air with the fuel rich fumes prior to ignition. This is followed by a refractory lined residence chamber operating with a flue gas temperature of 1450 to 1600 F.

Two (2) spark ignited oil burners will be provided to ensure ignition and stable combustion of rich fume. Input will be sufficient to maintain operating temperature when incinerating lean fume. The burners will be provided with ultra-violet flame scanners interlocked to shut down in the event of flame failure. High limit temperature control and low temperature contact for furnace interlock are provided as well as 1400 F flame sensor override contacts.

The combustion air for fume burning will be automatically controlled to pace the input of fumes from the furnace and maintain the residence chamber in the operating temperature range. The residence chamber thermocouple signal also regulates the burner input and dilution steam rate to the volatilization chamber so as to maintain the rate of volatilization in the correct range. Operating temperature will be recorded continuously.

b. Method of Operation

1) Mustard Filled

Operates as a rich fume incinerator. Ratings will be as follows:

	Rated Condition	Design
Mustard vapor, lbs/hour	1035	1294
MM Btu's/hour	8.3	10.4
Combustion air, scfm	4140	5175
Auxiliary fuel, gph	4	5
Start-up fuel, gph	20	20
Burner air, scfh	17,600	22,400

2) Drained

Operates as a lean fume incinerator. Auxiliary fuel is required to raise the gas temperature from 1000 F leaving the furnace to 1450 F leaving the fume burner. The operation will require a maximum of 20 gph of fuel oil for startup and approximately 4 gph for normal operation.

2. Auxiliary Fume Burner (AFB)

a. General Description

Fumes from the burn-out chamber and the flue gases from the PFB will pass through the auxiliary fume burner (AFB). This burner will raise the gas temperature to the nominal 1600 F afterburning temperature.

The AFB will be provided with a spark ignited oil-fired burner identical to those used on the PFB. Input will be sufficient to raise the gas temperature to 1600 F. A residence time of 0.5 seconds will be provided. The PFB combustion air blower will also supply combustion air to the AFB burner. The burner will be provided with an ultra-violet flame scanner, interlocked to close a safety shut-off valve in the event of flame failure. A high temperature alarm is also provided. The AFB oil burners will be supplied with 50% excess combustion air.

Burner input will be regulated by an automatic proportioning temperature controller.

b. Method of Operation

Operates as a normal fume incinerator burner, requiring 500,000 Btu/hour of auxiliary fuel input for normal operation. Ratings are as follows:

	Rated Condition	Design
Flue gas flow, scfm	5350	6700
MM Btu/hour input	0.5	0.6
Burner air, scfh	4400	5600
Auxiliary fuel, gph	4	5
Start-up fuel, gph	5	5

D. Air Pollution Control System (APCS)

The APCS is designed for automatic and continuous removal of gaseous and particulate pollutants from the MPF-Afterburner flue gas stream. The degree of gaseous and particulate removal is designed to meet or surpass the required emissions standards.

The system is designed to produce no liquid effluents and will minimize water consumption while maintaining a 20-25 weight % salt concentration feed to the salt dryers.

An analysis of the pollutants present in the flue gas stream led to the conclusion that both particulate and chemical scrubbing will be required to meet the emission standards. Particulate scrubbing will remove metallic oxide fumes and other particulates. Chemical scrubbing will remove acid gases, sulfur oxides and some of the nitrogen oxides.

Flue gas flow rates through the APCS will vary considerably for the different munition items and chemical agents being processed. Therefore, we have specified a variable throat area venturi scrubber and a constant differential pressure controller so as to maintain a high particulate collection efficiency over the flue gas flow range.

The design basis and design calculations for the various components of the ACPS are given in considerable detail in the Specifications Section of the Concept Design Report and will not be included herein.

The gas analysis flows and flow conditions at the interface between the MPF-Afterburner and the APCS are given in Table 3, "Fume Burner Exhaust". The applicable emission standards are listed in Table 4, "Emission Standards and Design Goals".

The various components of the APCS are shown in Drawing L-20, Process Flow Sheet and in Drawing 1722-2-D, APCS Design Flow Plan. The major components are the gas quench tower, venturi scrubber, scrubbing tower, exhaust blower, reheat burner stack, caustic tank, product brine retention tanks, salt dryer feed tank, salt dryers and associated pumps and instrumentation. The process stream conditions are given for various points in the APCS system in Drawing 1722-1-D.

Particulate removal is accomplished predominantly in the quench tower and venturi scrubber with minor additional removal in the scrubbing tower. Readily scrubbed gaseous pollutants will be largely removed in the quench tower and venturi while those requiring contact time will be removed in the scrubbing tower packed section. The bulk of the fumes will also be removed in the scrubbing tower packed section. The remainder will be eliminated by the scrubbing tower demister section.

1. Gas Quench Tower

a. General Description

The quench tower is a vertical counterflow vessel with upflow of the flue gases. The construction is shown on Drawing 1722-7-D and 1722-11-A. The design is such that at least 90% saturation of the flue gases is achieved before entering the venturi scrubber. This is essential to avoid loss in particulate scrubbing efficiency due to vaporization within the venturi as static pressure is reduced in the throat section.

The quench tower is provided with large, ported nozzles operating at low nozzle pressure by providing a large amount of excess quench liquor by means of a sump and pump-around system. The quench liquor is comprised of quench brine from the scrubbing tower plus fresh quench water make-up.

The tower diameter is selected so that, at design condition, entrainment will be approximately 3% of the entering quench water rate. This is very nearly equal to the additional water required to attain full saturation.

A level control is provided in the quench tower sump with excess brine returned to the scrubbing tower.

Emergency tower water will automatically enter the quench tower in the event of a commercial power failure or a high quench zone temperature.

b. Method of Operation

The quench liquor rate is set so that, to achieve 90% of the saturation at the design conditions, the tower height requirement is compatible with the elevation of the venturi scrubber.

The desired rate of demineralized well water make-up to the quench tower is that amount required to fully saturate the incoming hot flue gas. With the pumping around of excess liquor the make-up rate cannot be established by quench zone temperature control because wide swings in product salt concentration will be incurred as the flue gas flow rate varies. The make-up water addition rate will be controlled in response to two signals. The base line flow will follow the salts concentration in the scrubber sump. During Mustard processing, the water will also respond to the PFB air supply.

Both the make-up flow controller and the quench rate flow controller are equipped with remote set point capability to make changing to other control modes possible.

2. Venturi Scrubber

a. General Description

The general design features of the venturi scrubber are shown on Drawing 1722-8-A. Ninety percent (90%) saturated flue gas at 300 F from the quench tower flows axially into the top of the venturi scrubber. Large, cyclonic-inlet scrubbing liquor inlets without restricting nozzles are used in an enlarged diameter section to prevent plugging.

The venturi scrubber is provided with a variable area throat so as to maintain a constant pressure differential and high collection efficiency over a wide range of flue gas flow. Throat area modulation is achieved by using an electrical plug nozzle insert positioner actuated by the differential pressure controller. The throat section is flanged for ease of removal and provided with a side access port for internal throat inspection.

Calculated collection efficiencies are plotted versus particulate micron size for a number of differential pressure drops in Figure 5.

This figure shows that at least 99% collection efficiency can be attained for particulates down to 2 microns using the design differential pressure of 20" w.c.

b. Method of Operation

The venturi throat area is automatically adjusted by an electrically operated, axially positionable plug nozzle as previously described. Scrubbing liquor slurry is drawn from the scrubbing tower sump by a slurry pump and fed to the venturi scrubber inlet nozzles through a line equipped with a flow metering orifice and remotely adjustable flow controller. Scrubbing liquor flow must be set by the operator according to a pre-knowledge of the MPF-Afterburner system average flue gas flow conditions over a given operating period.

3. Scrubbing Tower

a. General Description

The scrubbing tower layout is shown on Drawing 1722-6-D. Arrangement of the associate piping and controls is shown on Drawing 1722-2-D. Flue gases enter the scrubber tower through a 90^{o} elbow followed by a baffled tangential inlet to minimize entrainment of the particulate laden liquid. A sump is located below the gas inlet.

A tilted chimney tray with bypass wash and bypass purge is installed above the gas inlet and is designed to minimize the particulate ppm level in the clean liquor. Above the chimney tray a packed tower section operates at 85% of

flooding velocity and is designed to give at least 90% SO_2 removal.

Clean liquor from the chimney tray is pumped to a weir trough distributor above the packed section of the tower. The packed section is followed by a demister section packed with 95% efficiency polypropylene packing. Phosphoric acid mist removal is accomplished in the demister.

A manually removable plate is provided in the demister support sheet to allow bypassing the demister at higher gas flow rates when phosphoric acid mist will not be present. A crinkled wire mesh screen is provided for entrainment removal when the bypass is open.

b. Method of Operation

Flue gases from the bottom outlet of the venturi scrubber enter the scrubber tower through a tangential inlet and flow upward through the tilted chimney tray and the packed bed. High SO_2 removal is achieved at 85% of flooding velocity and down to 20% of flooding velocity thus satisfying all system requirements under which SO_2 will be present. The upper section is provided with demisters for phosphoric acid removal.

Clean liquor is pumped from the chimney tray to the weir distributor above the packed bed. The sump liquor pH is monitored and a signal transmitted to a fresh caustic flow control valve connecting to the clean liquor recycle line.

Fresh water is provided on an intermittent basis to sprays arranged for cleaning the demister section. The demister cleaning water is drained to the sump.

The scrubbing liquor in the bottom of the scrubbing tower is maintained at a high salt concentration to eliminate the need for a pre-evaporator. Therefore, a high rate of recirculation is provided by the purge pumps. Part of the flow is returned to the bottom of the scrubber to maintain a suspension.

4. Exhaust Blower

The exhaust blower has been sized to provide adequate static pressure rise at the design flow rates. The backwardly inclined tip blade design has the following advantages:

The power requirement curve has a maximum and is non-overloading at high flow, low pressure.

The pressure-capacity curve is conducive to stable operation.

Efficiency is high, typically 65-80%.

To accommodate the high turndown requirement, the blower is equipped with inlet vanes positioned electrically by remote turndown control.

5. Reheat Burner

a. General Description

The stack reheat burner is sized to avoid a visible steam plume from the stack. The electrically ignited burner is an inline design located on the stack centerline and firing in the direction of flue gas travel. Fuel input can be adjusted manually to give a 4 to 1 turndown range. Automatic flame safeguard controls and alarms are provided and the burner will be shut down automatically in the event of flame failure, power failure, fuel or air pressure failure.

b. Method of Operation

The steam plume reheater is used only on days when the ambient conditions are such that flue product condensation produces a highly visible plume. The burner is controlled remotely from the control module and the operator will manually adjust the burner input at the minimum level to just eliminate the condensed vapor plume. The burner air-fuel ratio will be adjusted at 25% excess air to eliminate any visible flue product emissions due to incomplete combustion of the No. 2 oil.

6. Stack

a. General Description

The stack is a field-erected, self-supported pipe that discharges flue products 50 ft above ground level. It is designed to withstand 80 mph wind loading and is provided with sampling ports for emission monitoring.

7. Caustic Tank

a. General Description

A schematic layout of the caustic tank is shown on Drawing 1722-5-A. The general arrangement, piping and associated controls are shown on Drawing 1722-2-D. The purpose of the caustic tank is to provide an interface supply between the main caustic supply source and the APCS. The tank is sized for approximately 5 hours hold-up of 18 wt % sodium hydroxide at 125% of the normal flue gas flow rate. The tank is equipped with level control and an automatic blocking valve on the inlet.

b. Method of Operation

The caustic level in the tank is maintained automatically by operation of the inlet blocking valve. Flow of caustic to the scrubbing tower is regulated by a control valve actuated by the pH controller located in the sump of the scrubbing tower.

E. Brine Processing System

1. Brine Retention Tanks

a. General Description

Three (3) product hold-up tanks are provided to permit isolation, sampling, analysis and certification of the salt solution before routing to the salt dryers. Each tank is sized for 4 hours hold-up at 125% production rate with allowance for salt dilution to 20 wt %.

The general design features of the brine retention tanks are shown schematically in Drawing 1722-3-A. The general arrangement, piping and associated equipment are shown in Drawing 1722-2-D.

The recirculating pump on the scrubbing tower sump outlet line connects to the retention tank inlet header through a flow control valve actuated by the sump level control. The retention tank outlet pump is also equipped with a pressure control valve fitted recirculating line to provide thorough tank mixing inhibiting settling. Internal steam coils are provided to maintain the salt solution above its saturation temperature.

b. Method of Operation

Each retention tank is sized for 4 hours hold-up at 125% production rate. Discharge pumps are sized to empty a tank in 1 hour at the production rate and additionally to provide thorough tank mixing with 50% bypass. Therefore, the three retention tanks can allow continuous operation of the APCS even though one salt solution batch fails initial certification.

2. Salt Dryer Feed Tank

a. General Description

The general design features of the salt dryer feed tank are shown on Drawing 1722-8-A. The general arrangement, piping and associated equipment are shown on Drawing 1722-2-D.

The salt dryer feed tank is sized for 8 hours hold-up at 125% production rate with allowance for salt dilution to 20 wt %. The feed tank is equipped for caustic addition and pump-around agitation so that it may serve as a retention tank if necessary. Its pump is identical to the retention tank pumps and can empty the tank in approximately 2 hours. The flow rate from the feed tank to the salt dryers is set by a remote control valve which can receive its signal from the salt dryer control system. An internal steam coil is provided to maintain the salt solution above the saturation temperature.

b. Method of Operation

Salt solution is pumped to the salt dryer feed tank from the retention tank holding certified salt solution. The outlet pump feeds salt solution to the salt dryers at a rate about three (3) times greater than the drying capacity. The overflow salt solution is pumped back to the salt dryer feed tank.

3. Salt Dryers

a. General Description

Three (3) double drum dryers will be provided. The general arrangement of the dryers and associated equipment is shown on Drawing L-37.

The dryers are fed with salt solution from a common header connected to the salt dryer feed tank discharge pump. The salt dryer supply header may also be fed directly from any of the retention tanks. The salt is fed to a trough below the rotating drums and is splash fed to the surface of the drums which are revolving in opposite directions. Drying heat is provided by steam supplied to the inside of the drums. Dried salt is removed by the scraping action of knife blades. The blades are surrounded by a housing ducted to bag filters to minimize dust emission.

Dry product salt is collected in troughs and screw conveyor fed to a bucket elevator. Another screw conveyor transports the salt to a drum loader and compactor.

Exhaust steam is collected in a hood over each dryer and is vented through the building roof.

b. Method of Operation

The salt dryers will operate continuously 20 hours per day. Each dryer can produce 460 lbs per hour of dried salt. The feed rate is maintained at about three (3) times the evaporation rate for the three (3) dryers. The excess salt solution is pumped back to the salt dryer feed tank.

F. Effluent Gas Monitoring Station

1. General Description

A separate fully air conditioned room will be provided to house instruments and stack effluent agent monitoring equipment. The monitoring station will be provided with all necessary supporting utilities as described in the specifications section of this report.

Contractor furnished air pollution monitoring equipment will include:

SO_2 monitor (sample point No. 2)

Continuous O_2 monitor (sample point No. 1)

Chemical agent monitoring equipment will be Government furnished.

Each system shall be comprised of three (3) main functional groups: the sample probe and transfer line including sample pump and filters, the analyzer/recorder instruments and the alarm circuitry.

G. Water Supply

1. General Description

Analysis of the test results for the CAMDS water supply shows that treatment is necessary for use of the water as boiler feedwater. Also water use for direct contact quenching, demister back-flushing and level/pressure tap purging may require preconditioning.

The water supply and treatment system is shown on Drawing L-59, Process Water Schematic.

Well water is used directly for gas quenching, showers, floor washing connections, etc. Water for other process use passes through filters and water softeners and is pumped to a reverse osmosis unit. The treated water from the R.O. unit is fed to a head tank which stores water for emergency use as well as serving as a pump head tank for normal service. The waste water (blowdown) stream from the R.O. unit is fed to the quench tower along with filtered and softened well water.

Treated water pumps are supplied from the head tank and feed water to the MPF fog nozzles, hydraulic oil cooler, furnace internal door cooling circuit, boiler feedwater tank and the demister backflush connections.

H. Steam Supply

The steam and condensate return piping is shown schematically on Drawing L-58. Steam is supplied at 125 lbs per square inch from a package type boiler fully equipped to meet all insurance code requirements. The burner is equipped with ultra-violet flame supervision and complete safeguard protection is provided against failure of power, air and fuel pressure low boiler water. Other design features are described in detail in the Equipment Specifications Section of this report.

Steam is piped at 125 psig to the steam dilution nozzles on the MPF, to the three (3) rotary drum dryers, to the three (3) brine retention tanks and to the salt dryer feed tank.

A pressure reducing station provides steam at 15 psig for building and enclosure heating. Condensate from all process and building heating applications is returned to a condensate receiver tank. Treated water is also fed to the condensate receiver tank as boiler make-up water. The boiler feed water is pumped from the condensate receiver tank to the boiler as required by the water level control.

I. Operator Manning Table

A suggested manning table for this plant is presented as follows:

Personnel	Duties & Responsibilities
Supervisor	Coordinate operation with other modules Supervision of shift personnel Follows SOP in event of emergency Overall control of operations Prepares necessary reports
Operator A	Operates process control equipment Works in the Control Module Coordinates activities of subordinate operators Takes action in event of process upset
Operator B	Operates material handling equipment including MPL, charge car, burster loader, return conveyor Works in MHE Control Room Operates furnace doors and conveyor Monitors PDR trolley conveyor Operates projectile unloader Initiates action on tray handling anomaly Directs activities of MHE tender

Personnel	Duties & Responsibilities
MHE Tender	Monitors remote TV screens Operates MHE in place of OPERATOR B Works in MHE Control Room Assists BIF OPERATOR, loading bulk items on trays Maintains tray alignment for bulk items
Furnace Tender	Performs minor maintenance tasks Lights burners on start up Observes operation thru sight ports Lubricates furnace bearings, gear boxes Tends fans, hydraulic unit WORKS IN 6-LEVEL AREA
Forklift Operator	Operates forklift truck Transports bulk items to load point Assists BIF OPERATOR Works primarily in the BIF Module
Operator C	Operates furnace discharge car and scrap handling equipment Loads bulk item scrap on truck Operates projectile crane and electro-magnet Sequences furnace unloading on signal from OPERATOR A Works in scrap handling booth
Scrap Tender	Assists OPERATOR C Loads bulk scrap items Operates projectile scrap handling equipment Assists OPERATOR D and salt dryer tender to package and load salt drums
Operator D	Operates air pollution control and brine treatment Directs salt packaging and loading Directs salt dryer tender Tends scrubber subsystem Supervises certification and testing of brine

Personnel	Duties & Responsibilities
Salt Dryer Tender	Assists OPERATOR D Packages salt Loads salt drums on truck Unloads and handles empty salt drums Tends to salt dryers, minor maintenance and adjustment
Sampler	Samples brine in certification tanks Carries samples to chemical laboratory Performs miscellaneous tasks

J. Utility and Process Requirements

	Item	CAMDS Processing Mode			
		Bulk M	Bulk N	Proj. M	Proj. N
1.	Caustic @ 18%, gpm	5.9	.32	7.0	.26
2.	Steam @ 150 psi, lbs/hr	5370	220	5913	180
3.	Steam @ 15 psi, lbs/hr	1100	1100	1100	1100
4.	Power @ 460V, kw	350	350	350	350
5.	Emer. Power @ 460V, kw	150	150	150	150
6.	Well Water, gpm	12.4	3.7	13.6	3.3
7.	Primary Treated Water, gpm	11.9	3.2	13.1	3.0
8.	Secondary Treated Water, gpm	3.0	3.0	3.0	3.0
9.	Fuel Oil, gph	89.7	28.8	109	25.4
10.	Brine @ 80% H_2O, gpm	7.5	.37	8.3	.30
11.	Bone Dry Salt, lbs/hr	935	44.6	1031	36.5
12.	Salt Storage, ft^3	290	13.8	320	11.3
13.	Water Head Tank, gal	2880	2880	2880	2880
14.	Fuel Oil Tank, gal	2150	691	2620	610
15.	Caustic Tank, gal	1700	96	2100	78
16.	Salt Drum Storage, No	388	18.5	427	15.2

K. Design Approach for Shutdown Procedures

1. Introduction

Both planned and emergency situations will arise in any process operation requiring safe shutdown procedures. These procedures should be established before the final equipment design is undertaken to insure that adequate design factors have been followed and that controls are provided to execute the procedures. Reserve equipment must be provided to manage both utility and equipment failures where toxic agents or chemicals may cause personnel injury or equipment damage if not controlled. Furthermore, these procedures must be reviewed and expanded periodically during the course of the detailed design and fabrication phases of the project.

Emergency shutdowns will result from one or more of the following types of failures:

a. Electrical power
b. Water supply
c. Caustic supply
d. Steam supply
e. Fuel supply
f. Toxic gas release
g. Component failure

Emergency procedures will normally require an immediate cessation of production followed with an orderly shutdown of system components. In the case of the Metal Parts Furnace, containers and munitions being processed will be rapidly cooled with water fog nozzles and contained within the furnace in the event of an emergency shutdown. If sufficient time is available, in process items will be completed and a more deliberate shutdown will be executed. The fog water will be supplied at a rate of 14 gpm. This will cool the volatilization chamber and a full ton container from processing temperature to 200°F in less than five (5) minutes.

The restart procedures must provide for the situation where a partially filled munition exists within the furnace. After restoration of utilities, the process must be started in reverse to insure that the air pollution controls and the fume burners are fully operational before the furnace burners can be started.

Interlocks and supervisory controls will be included in the design to insure a safe start in any event.

2. Electrical Power Failure

a. Causes

1) Overloading

2) Short circuiting

3) Lightning, storm or fire damage

4) Human error

b. Necessary Provisions

1) System generating capacity design factor of 1.25.

2) Circuit breakers in branch circuits to prevent overheating of motor windings.

3) Lightning protection.

4) Emergency power supply available when the voltage is reduced to 70% of line voltage and within 5 seconds of the interruption. Equipment to be serviced by emergency power will include:

a) Boiler feedwater pump, auto start

b) Boiler blower and fuel oil pump, auto start

c) Boiler controls, auto start

d) Fuel oil pump, auto start

e) Combustion air blower and fan, auto start

f) Fume burner controls, auto start

g) Clean liquor pump

h) Quench brine return pump, auto start

i) Venturi slurry pump

j) Induced draft fan at reduced speed, auto start

k) Shroud isolation doors

l) Furnace hydraulic pump

m) Furnace drive

n) Treated water pump

o) Toxic agent monitoring equipment, auto start

p) Selected liquid and sample line tracing

q) Selected plant lighting, auto start

5) Afterburner combustion control delay timer to maintain ignition for up to 7 seconds to enable the emergency power system to react without loss of ignition.

6) Automatic reduction of afterburner fuel input to match reduced draft conditions.

7) Interlock with upstream modules to terminate further feeding of parts.

8) Safety shutoff valve to close air lines to furnace volatilization chamber.

9) Automatic solenoid opening in fog water line to the volatilization chamber.

c. Actions

1) Operating personnel should take immediate action prescribed by SOP for personal safety.

2) Manually start all utilities and systems connected to the emergency power system which do not start automatically.

3) Check to insure that fog water to the volatilization chamber has functioned. Manually, start the quench steam as a backup if the water flow is not established.

4) Monitor critical system indicators until safe conditions warrant shutdown of the fume burners.

5) Initiate final shutdown of remaining operating equipment.

6) Turn off water and steam purge systems when temperature falls to 200 F.

d. Alternate, Failure of Support System Power

Should a failure of an electrical device in an auxiliary equipment item such as a cooling chamber, scrap handling device, salt dryer, salt packaging item, etc., then a deliberate shutdown can be initiated. In this case, the operating cycle will be completed in the normal processing mode.

When processing projectiles, there will be three (3) trays to be processed. Fresh projectiles from the PDR should be stopped. The tray on the MPL should be loaded with projectiles in the trolley shroud. We estimate that 3 to 4 hours will be required to clear the system of agent filled projectiles.

When processing filled ton containers, we estimate that there will be a maximum of two (2) to be processed. They will require up to 8 hours to complete.

3. Water Supply Failure

a. Causes

1) Loss of a supply or recirculating pump.

2) Power overload to a supply or recirculating pump.

3) Flow blockage.

b. Necessary Provisions

1) Redundant pumps for caustic supply, caustic recycle, brine recycle, and treated water pumps.

2) System capacity design factor of 1.25.

3) Electric tracing of brine lines.

4) Heating of scrubber enclosure to prevent freezing.

5) Scrubber sump reservoir to provide reserve for shutdown.

6) Condensate receiver reserve to provide for safe boiler shutdown and 500 gallons for furnace purging.

7) Emergency water reservoir holding 500 gallons for backup of the fog water system.

c. Actions

1) Start redundant pump when applicable.

2) Terminate process operations to reduce system flows.

3) Initiate emergency shutdown procedure, continue fume burning.

4) Cool volatilization process with fog, automatically sequenced.

5) Use backup steam system to cool volatilization chamber if the water flow is interrupted.

6) Shut off fume burners when volatilization zone is suitably cooled.

4. Caustic Supply Failure

a. Causes

1) Failure of supply from ADS.

2) Failure of caustic pump.

3) Control failure (pH control).

4) Line break.

b. Necessary Provisions

1) Redundant pump for system supply.

2) Caustic storage (8 hours) in the MPF for a deliberate shutdown and for decon of brine in the certification tanks.

3) Fresh water backflush for sensing elements.

c. Action

1) Start redundant pump.

2) Determine if an ADS supply failure is expected to continue.

3) Start deliberate shutdown procedure if supply cannot be restored.

5. Steam Supply Failure

a. Causes

1) Boiler failure

2) Fuel failure

3) Steam line break or plugging

b. Necessary Provisions

1) All boiler services are tied into emergency power.

2) Ignition safety delay timer to maintain flame during a power dip and changeover to emergency power.

3) Emergency fuel supply for the boiler.

4) Condensate reservoir with 500 gallons of over capacity for reserve.

5) Standby water reservoir (500 gallons) and a fog water pump to back up boiler steam purge function in the volatilization chamber of the furnace.

c. Action

1) Attempt to restore boiler operation.

2) Initiate emergency shutdown procedure if boiler cannot be restored within a period of from 10 to 15 minutes.

6. Fuel Supply Failure

a. Causes

1) Fuel pump failure

2) Fuel filter blockage

3) Supply failure

b. Necessary Provisions

1) Redundant fuel oil pumps with automatic starting of the alternate when line pressure drops.

2) Dual filters, one in series with each pump.

3) Fuel storage tank remote level indicator with low level alarm.

4) Emergency fuel tank to serve boiler and fume burners for the time necessary to implement an emergency shutdown.

c. Action

1) Disciplined procedure for regular oil filter cleaning.

2) Disciplined surveillance of the fuel oil tank level.

3) Initiate deliberate shutdown procedure when the low level alarm is activated.

7. Toxic Gas Release

a. Causes

1) Fume burner flame out.

2) Loss of scrubber liquids.

3) Pipe or duct break.

b. Necessary Provisions

1) Toxic (6 level) ventilation of furnace and fume burner enclosure (shroud).

2) Emergency fuel for the fume burner.

3) Reserve of scrubber liquor in the scrubber sump.

c. Actions

1) Operating personnel should take immediate action prescribed for personal safety as prescribed by SOP.

2) Terminate production, start emergency shutdown.

3) Close all furnace openings.

8. Component Failure

a. Causes

1) Unreliable component.

2) Improperly serviced equipment.

b. Necessary Provisions

1) Selection of reliable components with a 1.25 design factor.

2) Detailed mechanical and electrical interlocks.

c. Actions

1) Disciplined maintenance program.

2) Continuous supervision of system operation.

3) Rigid procedures for production curtailment or cessation when warning signals indicate the probability of a failure.

V. GENERAL SPECIFICATIONS

A. Drawings

This specification prescribes general requirements for the preparation of engineering drawings and associated lists, and for application of Intended Use Categories for their acquisition. Commercial drawings for equipment will be used where they are adequate for the purpose. Engineering drawings as used in this specification, include engineering drawings and associated lists.

Drawing classification for this project will include:

1. Categories

Category B - Interface Control
C - Service Test
F - Procurement (Interchangeable Items)
G - Installation
H - Maintenance

2. Forms

Drawings for categories B and G will be Form 2, Drawings to Industry Standards (partial military control).

Drawings for categories C, F and H will be Form 3, Drawings to Industry Standards (minimum military control).

Quality Control for drawings will be in accordance with MIL-D-1000.

3. Drawings

a. The Contractor shall perform all drawing work on standard tracing cloth furnished by him and as per the format required by the Government. Any deviation from this procedure must be approved by the Contracting Officer.

4. Contents of Drawings

a. The Contractor shall engage design engineers, draftsmen, and all other personnel necessary to produce under supervision of professional engineers the drawings necessary to complete the design and construction details of the work prescribed in items of the specifications.

b. Machinery layout drawings shall be to ... material furnished on the drawings to define ... and commercial items.

c. Building element drawings, such as structural, foundation and architectural drawings shall be prepared according to the customs of the trades involved encompassing all information necessary to completely define the location, size of members and/or features, methods of attachment, etc.

d. Piping drawings shall be prepared in such a way to show pipe locations and elevations, valves, major equipment, centerlines at which piping is necessary and piping support system.

e. Electrical drawings shall be prepared by electrical engineers and draftsmen to show locations and sizes of conduit and wire, motor control centers, cable tray and other support accessories, control panels and all other physical elements of the electrical system. Moreover, they shall prepare schematic diagram for lighting, power and control for the entire project.

5. <u>Prints</u>

a. <u>Check Prints</u>

Furnish one reproducible print (Mylar) to the Contract Project Engineer for review of general layout and design of equipment before ordering equipment or beginning fabrication.

Review of drawings shall not be deemed as approval of departure from specifications unless listed in an accompanying letter at the time drawings are submitted for approval.

b. <u>Reproducible Prints</u>

Furnish one set of reproducible prints (Mylars) of all final drawings (assembly and details). All drawings will not release Contractor from full responsibility for interferences, errors or omissions and Contractor will be expected to furnish a complete and workable system to meet requirements.

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c. Measurements

The Contractor shall verify all dimensions as may be required to insure proper fitting and placement of all material and equipment furnished. Responsibility for accuracy of all measurements shall be the Contractor's and no extra charges will be allowed due to incorrect measurements. No extra charge will be allowed for minor differences between actual measurements and dimensions indicated on the drawings.

B. Codes and Standards

1. Workmanship

a. Piping

All piping shall conform to the American Standard Code for Pressure Piping, ASA B31.3, dated 1966 and to the military standard color code for pipelines MIL-STD-101B, dated 3 Dec 1970.

b. Welding

The design shall be prepared such that fabrication welding will be in accordance with MIL-STD-1261a, dated 30 Sep 1968.

c. Painting

The Contractor design shall be prepared such that fabrication painting will be in accordance with the following:

Certain surfaces will not require paint for protection. The following are examples of surfaces that shall be masked or otherwise protected during painting:

1) Machine surfaces that move with respect to each other, such as threads, slides, bearing contacts and gear teeth.

2) Electrical parts, such as contacts, relays, bearings, insulators, sockets, plugs, connectors, and terminals.

3) Plastic and rubber parts such as insulators, mounts, spacers, and windshields.

4) Lubrication fittings, cups and holes.

Painting shall be done in clean, dry, well-ventilated spaces. The air temperature shall be between 60 and 90 F and the relative humidity not over 65%. Materials shall be thoroughly mixed and there shall be no settling or separation of ingredients during painting. Unless otherwise specified, coatings may be applied by any method that will ensure the application of a smooth, uniform, continuous film, free from dried overspray, runs, sags, blisters, orange peel, or other imperfection. Freshly painted material shall not be exposed to conditions that will harm the paint. Surface preparation shall be in accordance with the manufacturer's specifications.

Filing, sanding or other dressing operations shall not be done on a part or assembly after it has been finished. Unless otherwise specified, welding, soldering and brazing shall not be permitted on an assembly after it has been finished.

d. Fastening

The Contractor design shall be prepared such that in all cases where equipment is secured in place by means other than welding, lock washers and/or vibration-proof fasteners shall be employed.

2. Safety Standards

The design of this equipment shall be accomplished so as to assure compliance with the Williams-Steiger Occupational Safety and Health Act of 1970.

3. Human Factors Engineering Standards

The design of the MPF System shall include human factors engineering to achieve simplicity, efficiency, reliability and safety of system operation and maintenance. "Human Engineering Design Criteria for Military Systems, Equipment and Facilities", MIL-STD-1472A, dated 15 May 1970 shall be used as a source for design criteria, principles and practices of human factors engineering.

4. Electrical Standards

The Contractor's design shall insure that all electrical hardware shall conform to NEMA Standards and all electrical installation methods shall conform to the National Electrical Code.

5. Building Standards

The MPF housing design shall comply with the latest editions of the "Specification for the Design Fabrication and Erection of Structural Steel for Buildings" and the "Code of Standard Practice" as shown in the most recent edition of the Manual of Steel Construction of the American Institute of Steel Construction, unless otherwise specified or indicated.

6. Furnace Standards

The design of combustion controls and wiring shall be in accordance with Factory Insurance Association (FIA) and Factory Mutual (FM) requirements.

7. Lighting Standards

MPF housing lighting shall be designed in accordance with the IES Lighting Handbook, 4th Edition.

8. Reference Standards

All work shall be done in conformity with all codes and standards that apply to this project. In the absence of a specific code, or where reference is made to the standard specifications of a technical society by initials, the latest edition of the specifications and standards of the following shall be used:

AASHO	American Assoc. of State Highway Officials
ACI	American Concrete Institute
ACGIH	American Conference of Governmental Industrial Hygienists
ADC	Air Diffusion Council
AGA	American Gas Association
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AMCA	Air Moving and Conditioning Association, Inc.
ANSI	American National Standards Institute, Inc.
ARI	Air Conditioning and Refrigeration Institute
ASCPP	American Standard Code for Pressure Piping
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWSC	American Welding Society Code
AWWA	American Water Works Association
FR	Federal Register - Department of Labor Occupational Safety & Health Standards - Safety & Health Regulations for Construction
CMAA	Crane Manuf. Assoc. of America

IEEE	Institute of Electrical and Electronics Engineers Incorporated
IPCEA	Insulated Power Cable Engineers Assoc.
IES	Illuminating Engineer Society
MSS	Manufacturers Standardization Society
NBFU	National Board of Fire Underwriters
NBS	National Bureau of Standards
NEC	National Electrical Code
NPC	National Plumbing Code
NSC	National Safety Council
SMAC	Sheet Metal and Air Conditioning Contractors' National Association
UL	Underwriters Laboratories
JIC	Joint Industrial Council

C. Manuals

1. Operating Manual

This manual will contain information describing the controls and instruments, preparation procedures, operating procedures, emergency procedures and shut down procedures. This manual will be in Contractor format.

2. Maintenance Manual

A maintenance manual will be prepared to delineate both maintenance procedures and schedules. Maintenance manual content will encompass preventative maintenance (including lubrication data and instructions) trouble shooting and repair procedures. This manual will be in Contractor format.

3. Safety Manual

The safety manual will be prepared to define equipment interlock requirements and detailed instructions for operator and equipment safety. This manual will be in Contractor format.

4. Spare Parts List

Spare parts will be listed in Contractor format and the following information will be furnished concerning each spare part:

a. Manufacturer's part number or drawing number.

b. Nomenclature and brief description.

c. Quantity used.

d. Location by referencing illustrations in manuals or drawings on assembly and subassembly drawings.

5. Training Manual

Pertinent sections of the operating manual, maintenance manual, safety manual and the spare parts list will be combined to form a Training Manual. This manual will be prepared using MIL-M-38784 as a guide for general requirements.

D. Warranty

The Contractor expressly warrants that all work performed and that all materials, machinery and equipment furnished under contract will be the best grade of their respective kinds for the purpose. The Contractor further warrants that the workmanship, materials, machinery and equipment furnished under this contract will meet the performance of function requirements as described in these specifications. Our approval of design, acceptance of work, materials, machinery and equipment shall not relieve the Contractor from the warranty set out in this paragraph.

E. Quality Assurance and Inspection Requirements

1. Inspection Location

Inspection by the Government shall take place at Tooele Army Depot, Tooele, Utah. However, the Government reserves the right to make preliminary inspection at the plant of the Contractor or designated subcontractor prior to final inspection at destination. Inspection, where made prior to acceptance, shall be merely for the convenience of the Government and without binding effect as to acceptance.

2. Government Quality Assurance Representative (QAR)

The authority of the QAR is limited to the responsibility for inspection. QAR's are not authorized to make changes of any nature in the contract requirements and any reliance upon direction or advice of any QAR as to contract changes shall be at the Contractor's risk.

3. Destructive Testing

Where destructive testing of items or components thereof is required by specifications or inspection clauses of the contract, the number of items or components destructively tested shall be in addition to the quantity to be delivered to the Government as set forth in the Specifications and all costs for destructive testing by the Contractor and items destroyed, as well as the cost of all other Contractor testing, are considered to be included in the contract unit price.

4. Contractor Responsibility for Performance of Tests

The Contractor shall perform the chemical and/or physical tests required in connection with the clause entitled "Inspection Requirements". The Contractor shall have available, the required testing equipment on his premises, the premises of his designated subcontractor, or in lieu thereof, the Contractor may accomplish the testing at a commercial laboratory having the necessary equipment and facilities and capable of performing the tests during the contract performance.

5. Welding

a. The welding specifications listed below are applicable. In the event of an inconsistency between provisions of this "Welding" clause and the provisions of the specifications listed immediately below, the inconsistencies shall be resolved by giving precedence to this Welding clause.

MIL-STD-1261A

b. Contractor shall conduct any necessary tests required to qualify or requalify the welding equipment and/or each welding operator in accordance with MIL-STD-1261A and utilize only the qualified welding equipment and qualified welding operators in performing any welding on specified equipment.

c. The Contractor shall maintain a complete record of the test results obtained from the qualification of the welding equipment and each welding operator. These records certified by the Contractor shall be available to the Government Quality Assurance Representative (QAR).

d. The Contractor shall not submit welded components to the Government Quality Assurance Representative for acceptance prior to receiving approval from the Contracting Officer of his welding procedures, nondestructive test procedures, and welder and welding operator qualifications.

6. Inspection Documentation

The Contractor shall submit inspection data in accordance with:

Quality Program Plan - Welding Procedures, No. DI-R-1710/M

7. Contractor Certification

The Contractor shall prepare on his letterhead or other suitable form a certification which shall include as a minimum:

a. Name of company, date of certificate, date of the test or inspection, and signature and title of certifying official.

b. Contract or purchase order number.

c. Complete nomenclature of supplies with lot numbers, or other identification, and the quantity in each lot or shipment.

d. Certificate(s) of analytical results for each test or inspection with the stated specification limits which indicate that the supplies meet the requirement of the contract for the following:

1) Painting of materials, finishes and fasteners are in accordance with Section B1, Workmanship.

2) Gas tight welding - furnace casing, quench, scrubber tower, ductwork, brine tanks.

3) Gas tight enclosures - furnace doors, shroud doors, air locks.

4) Programmable controller - multi-position loader.

5) Castings - trays, fixtures.

6) Fan performance - ID fan, combustion air blower, combustion air fan.

7) Pressure vessels - boiler.

8) Control functions - annunciator panel, relay panels.

9) Hydraulic - furnace hydraulic power unit.

10) Burners - electric ignition.

11) Emergency power generator - combustion time delay interlock.

e. The following statement certifying that the material supplied to the Government as covered by this certificate meets all the contract requirements: "The undersigned, individually and as the authorized representative of the Contractor, warrants and represents that: All of the information supplied above is true and accurate; the material covered by this certificate conforms to all the contract requirements; the analysis appearing herein is true and accurate; and this certificate is made for the purpose of inducing payment and with the knowledge that the information and certification may be used as a basis for such payment".

8. Certification Acceptance

a. The Contracting Officer may at his option accept those attributes certified to by the Contractor under the clause "Contractor Certification".

b. Notwithstanding any other provision of the contract, if the supplies for which the Contractor has furnished a certificate of conformance required by the contract are found not to conform to the contract requirement, the Government may, upon notice furnished within a reasonable time after discovery of such nonconformity, reject the supplies and require replacement thereof. Use by the Government of the Contractor's certificate of conformance does not preclude examination or test or both by the Government. Where a certificate has been furnished by the Contractor and the Government rejects the supplies, the Contractor shall have the right to request that a re-examination or retest be performed at the Contractor's expense.

c. Any certificate submitted by the Contractor is in addition to and not in lieu of any rights of the Government under this contract or law.

9. Inspection Requirements

a. The Contractor shall perform the examinations and tests of components and contract end item necessary to assure that requirements of drawings, specifications, and other contract requirements have been met prior to shipment.

b. Inspection for acceptance will be performed by the Government at Tooele Army Depot, Tooele, Utah, following assembly, installation, including tie-in to utilities and interface requirements (in the presence of the Contractor). The metal parts furnace shall function as required by drawings, specifications and other contract requirements. The metal parts furnace shall meet the production rate specified in the specification. Failure of the metal parts furnace to meet functional test shall be cause for rejection and the Government may require the Contractor to remedy the same by correction or replacement. The Contractor shall notify the Contracting Officer of the measure he proposes to use to correct the deficiencies.

F. Noise Control of Machines, Tools and Equipment

1. Sound Level Limit

Steady state* and/or cyclical sound* emitted by the source, as measured at the operators station and at all other required measurement locations, shall not exceed 85 dB(A) unless otherwise specified.

Impulse sound* emitted by the source as measured at the operators station and at all other required measurement locations, shall not exceed 130 dB peak sound pressure level.

*As defined in NMTBA Noise Measurement Techniques.

2. Instrumentation, Measurement and Reporting

The instrumentation, sound measurements and data reporting shall conform to the National Machine Tool Builders Association Publication, NMTBA Noise Measurement Techniques (June 1970) or to one of the following specific measurement techniques:

a. Pneumatic Equipment and Compressors

CAGI - PNEUROP Test Code for the Measurement of Sound from Pneumatic Equipment, first edition, Copyright 1969 by Compressed Air and Gas Institute.

The sound measurements for all small pneumatic machines as described in Section 5 of CAGI-PNEUROP Test Code shall be recorded with machine operating in "running-free" condition.

b. Electric Motors

IEEE Publication No. 85 Test Procedure for Airborne Noise Measurements on Rotating Electric Machinery as published by the Institute of Electrical and Electronics Engineers, Inc.

The "Average Sound Level Measurement" as described in Paragraph 7.22 of IEEE Publication No. 85 shall be reported for electric motors.

Reporting exception: The octave band data may be omitted and only dB(A) readings shall be reported if the dB(A) limit of Section F1 is not exceeded.

3. Requirements

The sound measurements and compilation of the required sound data shall be the responsibility of the supplier. The sound measurement data for standard products shall be submitted with the quotation. The sound measurement data for special purpose products shall be submitted as soon as it is available and before the product is shipped.

The purchaser shall have the option to verify sound level measurements at the supplier's facilities.

An exception to submitting data before shipment shall be considered where it is impractical to set up and test a complete machine in the supplier's facilities. The quotation shall state the conditions and make a request to perform the sound test in the purchaser's factory under agreed upon conditions. The supplier will remain responsible for meeting the sound level limit of this specification for the installed machine.

The quotation shall include as a separate detailed item any changes and associated costs required for a standard product to meet this sound level specification.

4. Alternate

It is not the intent of this specification to unduly limit suppliers or the design and performance capability of machines, tools and equipment. If the product does not meet the sound level limit of Section F1, the following shall be submitted:

a. Actual sound measurement data in accordance with Section F2.

b. Identification of probable sound sources.

c. Feasible sound level reduction through the use of auxiliary devices.

G. Noise Control of Air Moving Devices

1. Sound Level Limit

a. Fans - Ducted

The sound power levels for ducted fans, when operating at the specified volume flow rate and pressure, shall be determined by tests conducted in accordance with AMCA Standard 300, Test Code for Sound Rating Air Moving Devices and reported in accordance with AMCA Standard 301, Method of Publishing Sound Ratings for Air Moving Devices, and shall not exceed the following octave band levels:

Octave Band No.	1	2	3	4	5	6	7	8
Center Freq. Hz	63	125	250	500	1K	2K	4K	8K
PWL (dB re: 10-12 watts)	116	106	99	93	90	89	89	89

b. Fans - Non-Ducted

The loudness value in sones for non-ducted fans shall not exceed 40 sones when calculated in accordance with AMCA Standard 301, Method of Publishing Sound Ratings for Air Moving Devices, from sound power levels, at specified operating conditions, obtained in accordance with AMCA Standard 300, Test Code for Sound Rating Air Moving Devices.

2. Requirements

The sound measurements and compilation of the required sound data shall be the responsibility of the Company from which the A.M.D. is purchased.

The sound measurement data shall be submitted with the quotation.

3. Alternate

Auxiliary sound control devices shall be quoted when necessary to meet the sound level limit of Section F1.

H. Preferred Manufacturers

Below is a list of preferred manufacturers of equipment; in order of preference:

1.	Controls	Square D Allen Bradley Cutler-Hammer
2.	Motors	Westinghouse General Electric Reliance
3.	Capacitors	General Electric Westinghouse Federal Pacific
4.	Relays	Square D Cutler-Hammer Allen Bradley
5.	Motor Starters	Furnas Square D Allen Bradley
6.	Plugs, Connectors	Pyle-National Jay
7.	Pressure Switches	Mercoid Square D Allen Bradley
8.	Limit Switches	Square D Micro Cutler-Hammer Allen Bradley

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9.	Push Buttons & Indicator Lights	Square D Cutler-Hammer Allen Bradley
10.	TV Monitors	COHU Electronics, Inc. San Diego, Calif.
11.	Salt Dryers	Blaw Knox
12.	Process Instrumentation	Bristol L&N
13.	Hydraulic	Vickers
14.	Fans and Blowers	Chicago Blower General Blower
15.	Pumps	Gould Worthington Ingersoll-Rand
16.	Hoists	Harnischfleger American Loudin
17.	Bearings	Timken SKF MRC
18.	Gear Reducers	Winsmith Horsburg Scott Browning
19.	Chain & Sprockets	Browning Hewitt Robbins Rex
20.	Boilers	York-Shipley

FORM GEN - 81

I. Equipment and System Tests

1. Functional Test at Plant

The subcontractor/supplier shall conduct a functional test of specified subassemblies. The tests shall be performed with Government personnel present. Requirements for functional tests are set forth in Section VI, System Specifications.

For the test(s) all equipment shall operate continuously, for a period of not less than 6 hours, under simulated operating conditions without parts failure and without shut-down for parts, modifications or major adjustments. These test(s) shall be conducted entirely by Contractor personnel. The Contracting Officer shall be notified of the detailed schedule for these tests at least 2 weeks prior to their conduct. The Contractor shall correct any equipment defects or non-conformance with the contract at the Contractor's expense prior to shipment. The Contractor shall not ship any equipment to the erection site without specific written approval of the Contracting Officer.

2. Functional Test at Site

The Contractor shall conduct test of the entire assembled unit on site. The test shall be for the purpose of demonstrating to authorized Government representatives that the equipment is ready to begin the Acceptance Test phase of the contract. Seven days after completion of the test the Government shall provide emission mointoring support for the Acceptance Test. For the test all equipment shall operate continuously, for a period of not less than 6 hours without parts failure and without shutdown for parts, modifications or major adjustments. The Contracting Officer shall be notified of the detailed schedule for this test at least 7 days prior to its start.

3. Acceptance Test

An acceptance test of the combined system will be conducted by the Government at the prepared site South Area Tooele Army Depot monitored by the Contractor. The purpose of the test will be to checkout the operation performance of all facets of the system including emergency shut-down procedures. The acceptance test shall prove the ability of the system to meet material handling, thermal and emission requirements delineated herein. In an effort to be descriptive rather

than restrictive and in order to delineate to the Contractor the type of program which the Government envisions required to demonstrate the above capabilities, the following four segment test program is presented:

a. The ability of the Furnace Module to process large items shall be tested by successfully passing a minimum of 10 ton containers through the system. Since this shall be primarily a test of the material handling system, the Government shall not require the furnace to be fired.

b. The ability of the furnace to process filled projectiles and the Air Pollution Control Subsystem to meet particulate removal performance criteria shall be tested by successfully processing for 8 consecutive hours 155 mm projectiles at the rate shown in Table 2, "Munitions Configuration".

c. The ability of the Furnace Module to provide the required maximum heat output shall be tested by successfully processing for 8 consecutive hours empty 155 mm projectiles at the rate shown in Table 2, "Munitions Configurations".

d. The ability of the Air Pollution Control Subsystem to meet the chemical constituent removal criteria shall be tested by successfully processing for 8 consecutive hours Mustard filled 155 mm projectiles at the rate shown in Table 2, "Munitions Configurations".

J. Standard Specification for Painting

1. Scope

This specification includes the painting of all items of work furnished and/or erected by the Contractor.

2. Colors and paint specification shall conform with the following code of colors:

Code No.	Description and Specification
1	Light Green - Stran-Steel Siding, Color No. PV995.
2	Green - (Bldg. Mfgr.) Green
3	Black - (Bldg. Mfgr.) Black
4	Gray - Mahon Gray Oven-Baked Enamel Finish

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Code No.	Description and Specification
5	Light Green - Acme No. 293, or approved equal.
6	Black - Koppers Company Bituplastic Black #33.
7	Yellow - Acme No. 411 Lemon Yellow, or equal.
8	Red - Acme #418, or approved equal.
9	Dark Green - Acme #428, or approved equal.
10	Gray - Acme #406, or approved equal.
11	Red - Rust-Oleum #1210, or approved equal.
12	Aluminum - Rust-Oleum #1400, or approved equal.
13	Aluminum - Rust-Oleum #470, or approved equal.
14	Yellow - Rust-Oleum #659, or approved equal.
15	Green - Rust-Oleum #594, or approved equal.
16	Blue - Rust-Oleum #721, or approved equal.
17	Cream - Rust-Oleum #393, or Acme #410 Ivory Velunite.
18	Brown - Rust-Oleum #384, or approved equal.
19	White - Rust-Oleum #2766, or approved equal.
20	Black - Rust-Oleum #634, or Acme #421-B-4.
21	Ivory - One Coat Acme #872 Masonry Sealer and two finish coats of Acme #LE-6069, or approved equal.

3. Painting shall conform to the following schedule of colors:

Description	Color	Code No.
Siding (interior)	Light Green	1
Siding (exterior)	Green	2
Roofing (corrugated - interior and exterior	Black	3
Roofing (builtup - interior)	Gray	4
Structural Steel	Light Green	5
Gutters (interior)	Light Green	5
Gutters (exterior)	Black	6
Downspouts (exterior)	Black	6
Downspouts (interior)	Light Green	5
Handrailings		
Top Rail	Dark Green	9
All other parts of Handrail	Yellow	7
Ladders and Safety Cages	Yellow	7
Rolling Doors	Red	8
Man Doors	Dark Green	9
Floors (Motor Room)	Gray (Masterplate)	
Stairs (treads)	Dark Green	9
Channel Caps on Track and Truck Well Dock Walls	Yellow	7
Channel Caps on Conveyor Walls	Yellow	7
E.G. Set Structural Bases	Dark Green	9

Description	Color	Code No.
Embedded Stair Nosings	Dark Green	9
Machinery	Gray	10
Transfer Cars	Yellow	7
Electric Motors	Dark Green	9
Control Panels	Gray	10
Switchgear	Gray	10
Conduit	Red	11
Furnaces	Aluminum	12
Cranes, Crane Cabs, Hoists and Monorails	Yellow	7
Hydraulic Lines	Aluminum	13
Grease Lines	Aluminum (With 2" wide band of Yellow (Code 14 every 10 ft)	13
Lubricating Oil Lines	Aluminum (With two 2" wide bands of Green (Code 15) every 10 ft)	13
Low-Pressure Steam Lines (150#)	Aluminum (With 2" wide band of Green (Code 15) every 10 ft)	13
Fuel Oil Lines (Interior and Exterior)	Yellow (With 2" wide band of Green (Code 15) every 10 ft)	14
CAMDS Service Water Lines	Blue	16
Spray Water Lines	Blue (With three 2" wide bands of Yellow (Code 14) every 10 ft	16

Description	Color	Code No.
Fire Hydrants (Low-Pressure Service Water)	Red (With Hydrant taps and cap White (Code 19)	11
Compressed Air Lines	Green	15
Condensate and 15 psig Steam	Cream	17
L.P. Treated Feed Water	Cream (With 2" wide band of Blue (Code 16) every 10 ft)	17
Brine	Cream (With 2" wide band of Brown (Code 18) every 10 ft)	17
City Water	Brown	18
Drain Lines	Blue (With 2" wide band of Black (Code 20) every 10 ft)	16

All hangars to receive one (1) prime coat and one (1) finish coat to match interior building steelwork.

Cold water piping that will be covered, or insulated, shall be painted with one (1) coat primer.

All insulated lines shall be properly sized and painted with one (1) coat as per specifications.

All uninsulated lines shall be painted with one (1) prime coat and one (1) finish coat as per specifications.

All lines to be paint handed as called for in the specifications.

4. Color Code No. 6 shall have a minimum dry thickness of 12 mils. All other color codes shall have a minimum dry thickness of 2 mils unless designated otherwise.

5. All items shall be thoroughly cleaned in accordance with standards of the "Systems and Specifications" published by the "Steel Structures Paint Council" before application of either shop coat or field coat.

6. Red lead and oil touch up paint shall be applied in the field to cover any unpainted surfaces, field bolts, anchor bolts, etc., and any damaged paint or areas in which the thickness of shop coat does not meet the minimum 2 mils thickness.

7. All items listed under the schedule of colors shall receive both a prime or shop coat and a finish or field coat. Concrete walls shall receive two finish coats.

8. All items furnished and/or erected by the Contractor shall be painted. The color and paint for any item not listed in the schedule of colors shall be as directed by the Contract Project Engineer.

9. All paint applied in field shall be applied by brush method.

VI. SYSTEM SPECIFICATIONS

A. Material Handling Equipment

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the material handling equipment as specified herein.

b. The material handling equipment shall be installed by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The material handling equipment will be installed within a protective enclosure.

d. The material handling equipment shall be transportable by railroad flat car. It may be divided into subassemblies to meet this transportability requirement. When disassembled for transport, subassemblies shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Description

a. Trays and Fixtures

1) Trays

Trays will be cast using both heat and corrosion resistant alloy steel. The trays will be cast in 3'-0 wide by 2'-8" long sections and bolted together to form a full 8'-0 long tray.

By definition, a set of trays will include fifteen (15) 8'-0 long tray units. Two (2) sets of trays are to be provided.

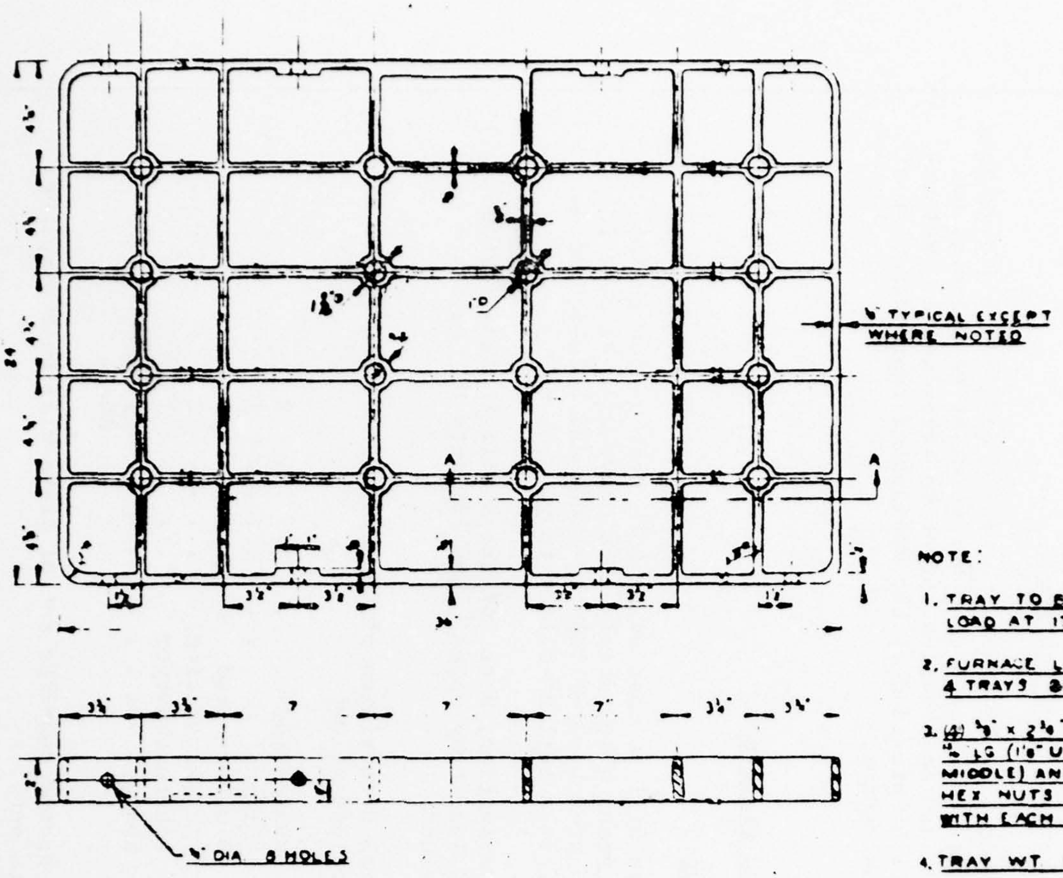
Normal disposition of the trays in a set will be as described below:

Charge end	2
Furnace	3
Discharge end	1
Cooling stations	2
Return conveyor	3
Spares	4
	15

The second complete set of trays will be a complete spare set.

Material to be cast 25 chrome - 20 nickel, ASTM Specification for Heat Resistant Steel Castings (A-297), grade HK.

Tray concept design data is included on Drawing sheet L-44.



NOTE:

1. TRAY TO BE DESIGNED FOR ... LOAD AT 1700°F
2. FURNACE LOAD TO CONSIST ... 4 TRAYS BOLTED TOGETHE...
3. (4) ⅜" × 2¼" LG. #330 STUDS, ... ¾" LG (1½" UNTHREADED ... MIDDLE) AND (4) ⅜ - UNC #330 HEX NUTS TO BE SUPPLIED WITH EACH TRAY.
4. TRAY WT 104# (EST)
5. MATERIAL ASTM A-297, G...

PUSHER FACES TO BE GROUND SMOOTH, TRUE, PARALLEL & AT RIGHT ∠ TO RIDING SURFACE.

SYM	DATE	CHANGED FROM	BY
A	8-6-74	AS ISSUED	R022

REVISIONS

CAMDS FURNACE

SURFACE COMBUSTION

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TRAY

ORDER NO. PC-1259

SCALE	DRAWN	CHECKED
5-1'	R022	R022

DWG. NO. - L-44

2) Fixtures

Fixtures will be designed for the following munition categories:

105 mm and 4.2" mortar projectiles
155 mm projectiles
8" projectiles
MC-1 bomb
MK-94 bomb
Spray tank
Ton container
Basket container for bursters and miscellaneous scrap

Sufficient fixtures in each category will be included to outfit two (2) complete sets of trays.

Material to be cast 25 chrome - 20 nickel, ASTM Specification for Heat Resistant Steel Castings (A-297), grade HK.

Concept design data forthe required fixtures is included on Drawings, Sheets L-22 and L-23. Dimensional data for the projectiles and bulk items is provided on these drawings.

b. Multi-Position Loader (MPL)

The multi-position loader shall be a programmable, manual, automatic or semi-automatic, bi-axial tray positioner for positioning 3'-0 wide x 8'-0 long trays on target beneath the Government furnished trolley projectile unload station. The operating surface of this loader will be a powered roller conveyor. This conveyor will be used to transport trays away from and back to the furnace charge car.

1) Physical arrangement of this loader shall be in accordance with dimensions and concept design data set forth on the Concept Design Drawing, sheet L-45. Supplier will design the entire loader sub-system including the programmable controller unit.

2) The loader will have a fabricated steel base for floor mounting. This base will be designed to have a smooth external contour and will have no cracks, crevices or cavities where liquid could collect.

3) The roller table surface of the loader will be built into the upper rigid frame, "FRAME NO. 2". The roller conveyor drive will be mounted on this frame. This frame will travel parallel to the 8'-0 long tray axis, the travel distance will be a nominal 8'-0 length. This frame will have V-groove guide roller wheels for supports.

4) "Frame No. 1" will ride on tracks provided by the lower rigid frame, "FRAME NO. 1". This frame will travel parallel to the shorter 3'-0 long tray width. This frame will have V-groove guide roller wheels for supports. The corresponding rails will be mounted on the lower structural base.

5) Power driven "Saginaw Ball Screws" will be provided to move the rigid frames. These ball screw drives will be powered by variable speed DC electric motors.

6) Limit switches will be provided to interlock the extreme travel positions.

7) A remotely located programmable controller and operator station will be furnished for either automatic or semi-automatic operation of the tray positioning operation. The programmable controller will be of the tape variety and will enable programming for the different loading patterns specified. Manual mode alternate required.

8) The overall sub-system, tray positioner and tape control will be able to repeat any position to a tolerance of plus or minus 1/4" of the nominal target point.

9) The loader will have a mechanical sensor to prove the empty position and to prevent double loading through a conventional interlock circuit with the Government furnished projectile unloader.

10) DC electric drives will be solid state, variable speed controlled.

11) Orientation of the projectile loading station will be as shown on Concept Design Drawing, Sheet L-45.

12) Compressed air will be available at 80 psig for operating the tray positioning clamps.

13) A cable reel will be furnished to coil the electrical powerand interlock leads required between FRAME NO. 1 and FRAME NO. 2.

14) A second cable reel will be furnished to coil the electrical power and interlock leads required between FRAME NO. 1 and the stationary electricl junction.

15) Cable reels will be provided to house and coil the compressed air hoses serving both rigid frames.

16) The entire sub-system will be shop tested and inspected prior to shipment to the site for installation. Supplier will provide special software for operating the controller to include programming tapes and instructions.

c. Charge and Discharge Car

Roller table surface tray handlers will be furnished for both loading and unloading the metal parts furnace. The powered roller table surface will be designed to handle 3'-0 wide by 8'-0 long trays. Further, the surface will have additional length to permit ready movement of the 11'-4" long spray tank item.

1) Physical arrangement of the tray handler shall be in accordance with the dimensional and concept design data set forth on the Concept Design Drawing, Sheet L-46.

2) The charge and discharge car tray handlers are to be interchangeable. Relocation of electrical power and interlock connections will be acceptable in keeping with the interchangeability requirement.

3) The tray handler will have a fabricated structural frame and support. The fabricated frame to have a smooth external contour and will have no cracks, crevices or cavities where liquid could collect.

4) The roller table surface will be power driven chain and sprockets will be used to drive the rollers.

5) The charge car will convey loaded trays both transversely from loading positions to the furnace centerline and horizontally into the furnace. This car is mounted on flanged wheels which ride on rails located on the floor. Movement of the car over the rails enables the transverse motion.

6) A cable reel is required to coil and house the electrical power and interlock control cables.

7) Complete design data is furnished with the concept design drawing.

d. Burster Conveyor

The burster conveyor will be a powered roller surface table for transporting and supporting work trays filled with projectile bursters.

1) Physical arrangement of this conveyor shall be in accordance with dimensional and design data set forth in the Concept Design Drawing, Sheet L-49. Supplier will provide the detailed design as well as the equipment.

2) The conveyor will have a fabricated steel frame suitable for floor mounting. The base will have a smooth external contour with no cracks, crevices or cavities where liquid could collect.

3) Electrical components and wiring will be "watertight" NEMA 4.

4) Complete design data is furnished with the concept design drawing.

e. Return Conveyor

The return conveyor will serve to convey empty trays from the discharge car back to the charge car. When processing bulk items, the return conveyor will serve as a loading station as well as a tray return conveyor.

1) Physical arrangement of this conveyor shall meet the dimensional and design data requirements of the Concept Design Drawing, Sheet L-50. Supplier will provide the detailed design as well as the equipment.

2) The roller table surface will be power driven.

3) Design data is provided on the concept design drawing.

f. Cooling Station

Two (2) cooling stations will be provided for cooling burned out projectiles and bulk items. Each cooling station will hold a loaded tray for cooling. Cooling will be by convection heat transfer. Powered fans will recirculate air from outside the enclosure, through the cooling chamber and back to the outside. Cooling will be augmented with hand controlled water sprays.

1) Physical arrangement of the cooling stations shall be in accordance with the dimensional and design data set forth on the Concept Design Drawing, Sheet L-47.

2) The cooling stations shall be identical.

3) The roller table conveyor surface will be power driven. Chain and sprocket drives will be used to drive the flanged rollers.

4) The cooling station will be designed to cool a loaded work tray from 1000 F down to 200 F. The design load will be a load of twenty seven (27) 8" projectile casings. Each station shall be capable of cooling the design load as specified herein within a 2 hour period. The designer may assume a weight of 309 lbs for the tray and 567 lbs for the fixtures. Each 8" projectile casing weighs 170 lbs.

5) For circulation of the cooling air, an axial flow fan is to be supplied by others. This fan shall be of the in-line, duct mounted style.

6) Design data is provided on the concept design drawing.

g. Cooling Station Ductwork

Inlet and outlet ductwork will be provided for the two (2) cooling stations. Individual fans are required for each unit, the outlet ducts may be combined downstream of the fans. The inlet ducts may be manifolded to a common duct.

1) The axial flow fans will be supplied separately (by others) from the ductwork. Certified dimension prints showing companion flange details will be furnished to the ductwork fabricator.

2) Fabricator to furnish ductwork as specified on the Concept Design Drawing, Sheet L-48.

3) Design data for the ductwork is provided on the concept design drawing.

h. Unload Station

A roller conveyor table will be provided for conveying and supporting tray loads of decontaminated scrap. This powered roller conveyor will position scrap items under the scrap unloading twin rail crane. The 20'-0 length of this unit provides additional surface to facilitate projectile unloading where the tray must be positioned beneath the electromagnet. Electrical controls will be provided to enable the scrap loadout operator to position the tray for either electromagnet unloading of projectiles or bulk items.

1) The physical arrangement of this conveyor shall meet the dimensional and design data as set forth on the Concept Design Drawing, Sheet L-50. The conveyor supplier will furnish the detailed design as part of the equipment procurement.

2) The roller table surface will be power driven as specified. Operator controls will be located in the discharge car MHE control room. Duplicate controls for positioning the trays will be field mounted adjacent to the conveyor for operator optional local control.

i. TV Monitor Equipment

TV monitors shall be provided for operator monitoring of the material handling system. Monitors will be placed in the MPL Control Room.

1) TV camera viewing locations will include:

a) MPL long axis (ventilated area).

b) MPL target position (ventilated area).

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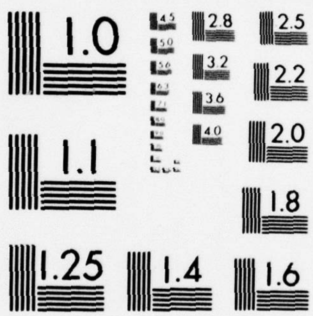

MICROCOPY RESOLUTION TEST CHART

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c) Burster well loading position (ventilated area).

d) Charge car tray handling area (ventilated area).

e) Bulk item loading station.

f) Discharge car tray handling area.

g) Punching chamber (ventilated area).

2) Component parts are to be furnished from Cohu Electronics, Inc., San Diego, Calif. Part numbers are itemized as follows:

a) Camera, with fixed lens	Model 2006-012
b) Camera, with 4:1 zoom lens	Model 2006-001
c) Pan/tilt Unit	Model PT550MX
d) Camera Control Unit	Model 3951-911
e) Lens Control	Model 2481-010
f) Pan/tilt Control	Model 2481-001
g) Monitor, 9"	Model SNA 9/2R
h) Monitor, 23"	Model SNA 23/Y
i) Amp, Distribution	Model 9800-162
j) Sync Generator	Model 2740-400

3) Field installation will be provided by the electrical subcontractor. Technical supervision will be provided by Government personnel at the CAMDS Site.

4) Conduits entering ventilated areas are to be sealed gas tight at the shroud wall interface.

j. Shroud Door Operators

Power driven door operators will be furnished as part of the material handling equipment sub-system. The door sequencing and interlocking is an integral part of the MHE operation.

1) Door operators will be required for the following door positions:

   a) MPL shroud door (ventilated area).

   b) Burster conveyor door (ventilated area).

   c) Bulk item air lock inner door (ventilated area).

   d) Bulk item air lock outer door.

2) Door operators will be electrically powered.

3) Limit switches will be provided to indicate both open and closed positions.

4) Operators will hold their position when the power is interrupted.

5) Conduits entering ventilated areas are to be sealed gas tight at the shroud wall interface.

k. MPL Control Room

Controls for the multi-position loader, furnace charge car, burster conveyor, furnace conveyor, shroud doors and the return conveyor will be located in the MPL Control Room. TV monitor screens will be located in this room. Motor controls for AC motors on the various conveyors plus DC power units for the MPL will be physically located in this room.

1) This room is to be furnished as part of the Enclosure Contractors scope of work.

2) The physical arrangement of the interior of this room shall be in accordance with the dimensional and design data set forth on the Concept Design Drawing, Sheet L-71. The Enclosure Contractor will be furnished with detailed layout information on the control equipment to be housed within this room.

3) The control room will be a prefabricated structure, suitably flanged for field assembly.

4) This room shall be approximately 12' wide x 25' long with a 9' ceiling height.

5) Windows will be provided along the east and south walls to permit operator direct viewing of the MPL and the charge car operations.

6) Detailed specifications for construction of this room will be included with Section O, "Enclosure" of the specification.

l. Discharge Car MHE Control Room

Controls for the discharge car, cooling station conveyors and the scrap handling equipment will be housed in the discharge car MHE control room. Motor controls for discharge area motors will be placed in this room.

1) This room will be furnished as part of the Enclosure Contractor's scope of work.

2) Physical arrangement of the interior of this room shall be in accordance with the dimensional and design data set forth on the Concept Design Drawing, Sheet L-71. Detailed layout information will be furnished to the Enclosure Contractor.

3) This control room will be a prefabricated structure, suitably flanged for field assembly.

4) This room shall be approximately 12' wide x 14' long with a 9' ceiling height.

5) Windows shall be provided along the north and west walls to direct operator viewing of the discharge car and scrap loading operations.

6) Detailed specifications for construction of this room will be included with Section O, "Enclosure" of this specification.

m. Scrap Handling Equipment

The scrap handling equipment will consist of a bridge crane, a raised deck trolley, a hoist unit, a set of projectile electromagnets and a set of bulk item magnets. Electromagnets are attached to the top running type crane hoist for vertical lifting scrap projectiles out of the fixture cavities on the trays. The load of projectiles is conveyed horizontally to the waiting scrap truck by the

overhead crane system. Projectiles are deposited into the truck by releasing the electromagnet. Bulk items are lifted similarly from the fixtured tray on the unload station, using electromagnets to grip the scrap item. The rail crane unit is used to convey the bulk items to the truck.

1) Physical arrangement of the scrap handling equipment shall be in accordance with the dimensional and design data set forth on the Concept Design Drawing, Sheet L-53.

2) The hoist capacity shall be 6000 lbs.

3) Hoist service classification - Class D (Min.).

4) Speeds - hoist 30 fpm, trolley 45 fpm, bridge 60 fpm.

5) The hoist shall meet the standards of the CMAA and ANSI B30, November 1973. The electric hoist shall have upper limit switch, motor and eddy current load breaking as well as secondary direct acting motor brakes.

6) Positive stops will be provided at the crane rail extreme runout points.

7) The hoist, magnet and trolley controls will be remote. Dual controls will be provided, one (1) set in the discharge car control room and the other field mounted for remote operator control.

8) Crane motors will be wound rotor, hi-starting torque, TENV, designed for crane service and rated at 30 minute 75 C temperature rise.

9) Both main line and bridge conductors shall be enclosed, insulated type.

10) The crane system will be field tested to show that they can meet the specification and lift a load equivalent to 125% of rated capacity.

11) Special magnets will be provided for the ton containers. Hooks and grab bars will be used for the bomb MC-1, bomb MK-94 and the spray tank.

12) Special electromagnets will be provided for projectiles.

13) Electromagnets will be provided with back-up, fail safe, battery power, to retain the load in the event of a power failure.

14) Full size inert samples of the projectiles and the bulk items will be furnished by the Government to the magnet supplier for use in the final detail design of the electromagnets.

6. Standard Specifications for Equipment

a. General

1) It is the purpose of this specification to define standards for chemical demil equipment to be designed for CAMDS. Equipment shall be designed for continuous operation with a minimum of required maintenance.

2) Where a specific supplier or manufacturer is mentioned, an equal may be substituted, subject to approval by the Purchaser.

b. Mechanical Equipment

1) All equipment shall be heavy duty, mill type construction, rated for 24 hour service. The design factor shall be 125% of the rated load requirement.

2) All materials used in the construction of this equipment shall be selected for physical and metallurgical properties, with necessary heat treatment, to be consistent with Item 1.

3) All exposed moving parts, couplings, etc., shall be provided with removable safety guards.

4) All like parts on machines or equipment, or on similar machines or equipment shall be interchangeable.

5) Adjustments shall be made from the operator's side of the equipment insofar as practical.

6) Operating adjustments are to be arranged so that the use of tools (i.e., wrenches, etc.) by the operator is not required.

7) All bearings for rotating parts shall be anti-friction, unless otherwise approved. All pillow blocks, etc., shall be cast iron.

8) Bronze bearings shall be used for sliding parts.

9) Gear reducers shall be heavy duty, cast iron or welded steel construction.

10) All gear type couplings size 6 and smaller, to be Faulk.

11) All gear type couplings larger than size 6, to be Fast's.

12) Leveling screws to facilitate installation shall be provided.

13) All gear boxes and gear reduction units to be subbase mounted.

14) Equipment setting on concrete foundations to be provided with suitable grouting lugs.

15) All necessary hose reels, cable reels, powertrak, etc., are to be furnished where required.

16) All necessary rails or tracks for charge cars, etc., are to be furnished where required.

17) Elevated drives or other mechanical components are to be supported by steel structures extending to floor elevation.

18) All structures furnished to support equipment, etc., are to be provided with suitable access platforms and stairs. (Ladders will be acceptable only when space limitations do not permit stairs).

c. Lubrication Equipment and Systems

1) Centralized greasing system (Trabon, or approved equal) with pneumatic grease pump (Lincoln, or approved equal) shall be provided to service the equipment furnished.

2) Manual greasing may be used on points requiring packing at no less than semi-monthly intervals.

3) Oil lubrication systems for the various pieces of new equipment shall be provided as part of that equipment.

4) Drip lubricators and spray lubricators are to be provided where required for roller chain applications, etc.

B. Metal Parts Furnace

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the metal parts furnace (MPF) as specified herein.

b. The furnace assembly shall be erected by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The furnace will be installed within a shrouded area which is housed within a protective enclosure. Ambient conditions within the shrouded area will range from 50 F during extended winter shutdown periods up to 200 F during summer operating periods.

d. The furnace subassemblies shall be transportable by railroad flat car. Flanged subassembly breakdown shall be approximately as shown on the Concept Design Drawing, Sheet L-2. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

e. The unit shall be shop tested prior to shipment to the installation site. Testing will consist principally of firing the volatilization and burnout chamber burners. The test fuel shall be No. 2 fuel oil.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Components

The furnace shall be of the roller hearth type. This furnace will be oil fired with burners suited to burning No. 2 fuel oil and having electric ignition. The roller hearth shall be power driven with external motors, speed reducers and a chain and sprocket drive.

The work pieces will be supported on alloy trays equipped with suitable fixtures. The trays will be conveyed through the furnace by the power driven rollers.

The Metal Parts Furnace will be made up of three zones: an uninsulated punching vestibule, a refractory lined heating chamber for controlled volatilization of agents, H, HD, HT and a second refractory lined heating chamber for final burnout of all agents. The furnace chambers will be separated by vertical lift inner doors.

The heating zones of the furnace will be provided with air atomizing oil burners arranged to give direct impingement of steam diluted combustion products on the sides of the bulk containers (ton containers and spray tanks). Sufficient steam will be used to give tempered flame operation and minimize development of hot spots on the container walls. The burners will operate at a slightly rich, controlled air/fuel ratio to prevent introduction of oxygen into the furnace.

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The furnace shall be designed for automatic and continuous processing of trays containing twelve (12) munitions as set forth on the "Munitions Matrix for Metal Parts Furnace", Drawing Sheet L-38. The configurations of each of these munition items is set forth in Table 5 of this specification with loading patterns shown on Drawing Sheets L-22 and L-23.

TABLE 5

WORK PIECES

No.	Munition	Length	Diameter	Metal Weight	Rate	Items Per Tray
1	M360 105 mm	15.7"	4.223"	27.7 lbs	60/hr	70
2	M121A1 155 mm	22.84"	6.22"	79.7 lbs	40/hr	44
3	M122 155 mm	22.84"	6.22"	83.55 lbs	40/hr	44
4	M426 8"	29.05"	8.284"	158 ±1.7 lbs	24/hr	27
5	M60 105 mm	15.79"	4.223"	26.58 lbs	60/hr	70
6	M2/M2A1 4.2"	16.01"	4.2"	13.67 lbs	60/hr	70
7	M110 155 mm	23.8"	6.22"	80.0 lbs	40/hr	44
8	M104 155 mm	23.8"	6.22"	74.0 lbs	40/hr	44
9	MC1 Bomb	51.4"	17"	435.0 lbs	2/hr	1
10	MK94 Bomb	60"*	10.75"	278.0 lbs	1/hr	1
11	Spray Tank	136" (excluding tail)	22.5"	500.0 lbs	0.25/hr	1
12	Ton Container	81.5"	30"	1600.0 lbs	0.25/hr	1

*Dimension scaled from drawing.

The furnace shall be gas tight to prevent leakage of toxic vapors. It shall operate with a negative pressure of approximately 0.2" w.c. created by an induced draft fan which is part of the air pollution control system. All components will be designed to provide low maintenance and reliable operation. All furnace operations will be done remotely with limited visual surveillance. Major furnace operations will be interlocked and sequenced to avoid mishandling or contamination. This will include interlocks with the material handling equipment and the fume burners.

The approximate furnace dimensions are shown in Table 6.

The furnace will be supplied with the following utilities:

Combustion Air	818 scfm @ 16 oz
Fuel Oil	25 gph @ 400 psig
Steam	75 lbs/hr @ 125 psig
Cooling Water	1.0 gpm @ 20 psig
Electric Power	460V, 3 phase, 60 Hertz

TABLE 6

DIMENSIONS

Punching Chamber

Width - wall to wall	4'-0"
Effective width	3'-0"
Height - floor to roof	8'-0"
Length - door to door	15'-0"
Maximum work and tray height	2'-7 1/2"
Center to center - punches	5'-0"
Center to center - conveyor rolls	1'-0"
Overall height (furnace)	6'-10"
Overall height (charge door hoist)	11'-8"

Volatilization Chamber

Width - wall to wall	4'-0"
Effective width	3'-0"
Height - floor to arch springline	6'-1"
Length - wall to wall	13'-0"
Overall length - door to door	15'-7"
Overall length - assembly flange to flange	18'-0"
Overall height (furnace)	8'-6"
Overall height (door hoist)	13'-3"
Wall thickness (IFB)	0'-9"
Center to center - furnace rolls	1'-0"

Burn-out Chamber

Width - wall to wall	4'-0"
Effective width	3'-0"
Height - floor to arch springline	5'-7"
Length - wall to wall	13'-0"
Overall length - door to door	14'-6"
Overall length to assembly flange	14'-4"
Overall height (furnace)	8'-0"
Overall height (discharge door hoist)	11'-8"
Wall thickness (IFB)	0'-9"
Center to center - furnace rolls	1'-0"

a. Punching Chamber

The punching chamber is a gas-tight uninsulated metal housing surrounding the bulk container punching station. It is equipped with power-driven rollers to convey the loaded work trays to a fixed position beneath the punches determined by the tray tripping a flag switch located between conveying rollers. The entry end of the punching chamber contains a hydraulically actuated, vertical lift door which is electrically interlocked with other system components as previously described. The discharge end is flanged for modular transportability of this part of the furnace assembly. The punching chamber is vented by a duct leading to the PFB and is ventilated at the rate of 25 air changes per hour as required for areas where agent spills and agent vapor emission are anticipated. A typical chamber section is shown on Drawing, Sheet L-29.

1) The punching chamber casing will be fabricated of carbon steel plates, suitably reinforced with structural steel buckstays.

2) The internal walls of the chamber shall be coated with a corrosion resistant coating to allow washing with sodium hydroxide or sodium hypochlorite solutions for decontamination.

3) The floor of the chamber shall contain three (3) drains to remove the decontamination solutions.

4) There will be a remote controlled, closed circuit television camera and a lighting fixture to monitor the punching operation.

5) There will be limit switches to note the tray position, door up, and door down positions.

6) There will be a damper in the pipe leading to PFB that automatically closes when the outer door opens. The damper controls the chamber pressure at -0.1" w.c. during the time the doors are closed.

7) The outer door shall be constructed of metal with a wedge type locking device to prevent excess leakage.

8) The door will be opened by an electrically actuated hydraulic lifting device.

9) There shall be a temperature indicator and high temperature alarm.

10) The outer door will be interlocked to prevent opening without sifficient draft.

11) There shall be two (2) sight ports to monitor the punching operation.

12) The outer door shall have limit switches to detect door up and door down positions.

b. Punch System

The purpose of the punch system is to provide openings at each end of the ton containers for release of agent vapors without internal pressure buildup during the volatilization period. The punch system consists of the two hydraulically actuated punches passing through seals in the roof of the furnace with correspondingly located anvils beneath the support tray which elevates the load support tray to a position above the conveyor rolls and provides support to the punch section of the bulk container during the punching operation. The design of the punches and the corresponding punch control circuits will be very similar to the system now in satisfactory operation at RMA, Building No. 538.

1) Two (2) electrically actuated, hydraulically operated punches to place approximately 4" triangular holes in the ton containers will be provided.

2) The punches shall be provided with limit switches to detect the punch up and punch trough position.

3) Two (2) anvils will rise through seal glands in the floor of the furnace to support the tray during the punching operations.

4) The anvils will have limit switches to detect the anvil up and anvil down positions.

5) The punches shall be equipped with sealing collars to duct any high pressure gases escaping during the punching operation to the PFB.

6) The operation shall be interlocked so that the tray is in position, the anvil up, the collar down, and the door down prior to punching.

c. Volatilization Chamber

The volatilization chamber is a refractory lined chamber containing eight (8) oil fired burners. It is designed to heat the work quickly to the boiling temperature and then hold it at that temperature to produce a controlled volatilization rate in an oxygen-free atmosphere. The primary temperature control during the volatilization period will be from the temperature of the burning vapors in the PFB. It is equipped with steam injection and water fog nozzles to control excursion of the boiling rate. A typical furnace section is shown on Drawing, Sheet L-29.

1) The chamber shall be fabricated from carbon steel plates suitably reinforced with structural buckstays. It shall be lined with 9" of 2300 F insulating firebrick with an arched roof. The chamber shall be gas tight.

2) There shall be three (3) burner control systems, two (2) on the volatilization burners, and one (1) on the heat-up burners.

3) In addition to the normal flame safety systems, all of the burner manifolds shall have manual reset safety shutoff valves in the combustion air lines.

4) Steam shall be added to the chamber continuously to facilitate purging. Additional steam will be added if there is an over temperature in the PFB.

5) Water fog nozzles will be used to rapidly cool the chamber during an emergency shut down.

6) There will be water cooled doors at either end of the chamber equipped with locking devices to prevent leakage. The doors will be electrically actuated, hydraulically operated with a vertical lift.

7) There will be limit switches to detect the door up and door down positions.

8) The door will be interlocked to prevent opening during the volatilization process, and sequenced for safe tray handling.

9) There will be four (4) access ports for scrap cleanout from the furnace floor.

10) There will be a damper in the line to the PFB to maintain the chamber pressure at -0.2" w.c.

11) There shall be two (2) sight ports to observe the furnace operation.

d. Burn-out Chamber

The burn-out chamber receives items from the volatilization chamber to burn out any residual sludge in an oxygen bearing atmosphere. There are four (4) burners controlling the chamber temperature between 1000 and 1200 F. When the parts leave the chamber, they will be completely detoxified.

1) The chamber shall be fabricated from carbon steel plates suitably reinforced with structural buckstays. It shall be lined with 9" of 2300 F insulating firebrick with an arched roof. The chamber shall be gas tight.

2) There will be one (1) burner control system. The burner shall have the standard safety systems.

3) Water fog nozzles will be used to rapidly cool the chamber during an emergency shut down.

4) There will be a refractory lined outer door with a locking device to prevent leakage. The door will be electrically actuated, hydraulically operated with a vertical lift.

5) There will be limit switches to detect door up and door down positions.

6) The door will be interlocked to prevent premature opening.

7) There will be two (2) access ports for scrap cleanout from the furnace floor.

8) There will be a damper in the line to the auxiliary fume burner that partially closes when the discharge door is open and controls the chamber pressure at -0.1" w.c. during processing.

9) Two (2) sparge air ports will be located over the punched holes in the ton container. The sparge air will be initiated from a cycle timer.

10) There shall be two (2) sight ports to observe the furnace operation.

e. Roller Hearth Conveyor

The work pieces loaded on fixtured, articulated support trays will be carried through the furnace on power driven rollers extending through the side walls of the furnace, and mounted in flanged ball bearings of the self-aligning type. These bearings will be bolted to adapters, which will be bolted to the furnace casing.

1) All the rollers within the punching chamber and furnace chambers will be made of corrosion resistant alloy and, in the case of the furnace chambers, heat- and corrosion-resistant alloy will be used.

2) The furnace rolls will be 6" OD with 3/8" wall thickness. The furnace rolls will be centrifugally cast and the finish will be as 'cast'.

3) The rolls will be capable of supporting a maximum loading of 5000 pounds per 3' x 8' tray at 1400 F.

4) The rolls will have aluminized alloy trunnions welded to the alloy roll barrel to make a suitable connection for alloy operating in a rich hydrocarbon atmosphere. Aluminizing the roll trunnions prevents carbon attack on the trunnions in the colder wall area.

5) Each roll will be provided with a sprocket attached on one end. The sprockets will be chain-driven roll-to-roll.

6) Bearings will be flanged pillow block ball type, anti-friction with external lubrication. Each bearing will be bolted to finned adapters for cooling.

7) The bearings should be purged with dry air to prevent condensation of acid gases contained within the furnace volatilization and burn-out chambers.

8) The main furnace conveyor drive will be a single speed, rapid movement for transferring work from the charge car into the furnace chambers. This drive will have a 1 hp, 1200 rpm, MAC, TE.FC. electric motor complete with speed reduction unit, shafting, sprockets, clutches and structural support base.

9) Electric clutches are provided to isolate the various furnace chambers to permit operator manipulation for startup, shutdown and interim processing.

10) The drive mechanism shall include sprockets, idler sprockets, chain idlers, prestressed roller chain, and a main drive shear pin.

f. Hydraulic Systems

The hydraulic system is specified on the Concept Design Drawings, Sheets L-42 and L-43. Detailed specifications shall be as follows:

1) Reservoir to be fabricated from steel plate, welded construction, sand blasted and prime coated and finished painted inside and outside with machine grey paint.

It shall have acapacity of 60 U.S. gallons.

It shall be furnished with two (2) clean-out covers and a removable baffle plate. Clean-out covers shall be furnished with a magnetic drain plug located in the flow path around the ends of the baffle plate.

Bare unfurnished reservoir to be mounted on legs or formed feet so that bottom of tank is supported 6" above floor.

Top of reservoir to be furnished with mounting plate large enough to mount both pump and electric motor with three point mounting to prevent distortion.

Pump and motor with flexible coupling and detachable guard shall be mounted on mounting plate without distortion.

Pump and motor shall be aligned to within 0.005" runout.

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Furnish top of reservoir with 2" NPT return inlet and two (2) 1/2" NPT drain return couplings with internal piping to extend below fluid level.

Return pipe to bevel cut at bottom and turned to direct fluid flow alongside of reservoir for cooling.

Furnish with removable filler cap with internal screen and air breather.

Furnish side of reservoir with sight level gauge to show high and low levels.

A temperature gauge shall be mounted near sight level gauge.

All patch type covers over openings to be gasketed for protection against dirt.

2) Panel shall be fabricated from formed and stamped steel plate, flanged and bolted together, inside of a structural steel frame and attached to reservoir.

All control valves to be mounted on face of panel with fluid connecting lines in back over pump and motor.

Cylinder terminal points or connections shall terminate with 3/4" NPT 2000 lb steel couplings welded to a horizontal plate for overhead bridging to furnace.

Paint structural frame with an oil resistant machine grey paint.

3) Power unit with control panel shall be protected with adequate guard rail to prevent damage frommaterial handling equipment.

Remove clean-out covers and thoroughly clean inside of reservoir before replacing covers and filling tank.

Pressure test piping with power from power unit and cylinder terminals plugged.

4) Valving shall be arranged so that all controls are accessible for adjustment and maintenance.

All panel components shall be identified to show motions, pressures and purpose.

5) Cylinders shall be located in alignment with work slides and installed so that no side or radial load occurs on piston rod.

They shall be accessible for piping and easy service and maintenance.

6) Circuit shall be tubed with annealled and pressure tested welded stainless steel hydraulic tubing.

Each tubing run shall be continuous from one component to another.

Couplings shall be used only where necessary for length or assembly.

Tubing shall be 1/2" x 0.049 wall for drain lines to headers.

Tubing shall be 3/4" x 0.065 wall for pressure lines to cylinders and return lines through valves to header.

Tubing shall be 1" x 0.083 wall for panel return header.

Use clamp type brackets with inserts to support tubing runs every 4 to 5 feet.

Inserts to be of a material that will not damage tubing.

Fitting shall be bite type steel hydraulic fittings suitable for shock loads.

7) Piping shall be schedule #80 (double strength) for all pressure lines.

Fittings shall be 2000 lb forged steel fittings for all pressure joints.

Return line pipes and fittings may be schedule #40 (standard weight).

Teflon tape shall be used on all pipe threaded connections. (Not required for tubing connections).

Piping shall not support valving or other component parts, except shut-off valves mounted adjacent to equipment.

No piping shall be welded to a supporting member.

8) All hydraulic runs shall be installed so as not to interfere with the adjustment, repair, removal or replacement of any control or unit.

All hydraulic runs shall be located or protected so as to prevent damage from moving machinery or from climbing.

Hydraulic components and piping shall not be subject to excessive temperatures or other detrimental effects.

9) Electrically controlled hydraulic components shall be applied so that in the event of an electrical failure, there will be no damage to the equipment or danger of injury to personnel.

Vertical motions shall be provided with means to prevent rapid drop when hydraulic or electrical power is off.

All motions shall be controlled by mechanical actuated type limit switches.

All components shall be furnished for use with petroleum base hydraulic fluid.

Complete circuit with components shall be designed for 2000 lb maximum service.

10) The hydraulic unit shall be placed within the 6-level furnace shrouded area. A special shell and tube, water cooled, heat exchanger shall be furnished to cool the hydraulic fluid.

g. Burners

The burners shall be designed to burn No. 2 fuel oil using 16 osi combustion and atomizing air and be direct spark ignited. The ignition must be reliable since some burners will be relited once every hour. The burners shall have metallic air housings and a heat resistant refractory burner block that extends through the furnace insulation. They shall have the following capacities:

Burner No.	Function	Oil Rate
B03 A,B,C,D	Volatilization Impingement	2 gph
B04 A,B,C,D	Volatilization Heat-up	2 gph
B05 A,B,C,D	Burn-out	3.7 gph

1) The burners shall be capable of operating over the range from 10% deficient to 100% combustion air and be capable of operating down to 1/4 of rated capacity.

2) There will be an ultraviolet flame sensor on each burner. The sensors shall be connected in series in the following manner:

Flame Sensor Control 1	Burners B03 A,B
Flame Sensor Control 2	Burners B03 C,D
Flame Sensor Control 3	Burners B04 A,B,C,D
Flame Sensor Control 4	Burners B05 A,B,C,D

3) The burners shall be equipped with:

a) Combustion air motorized control valve.

b) Low pressure combustion air switch.

c) Oil ratio control regulator back loaded to the combustion air supply.

d) Low and high oil pressure switches.

e) Oil manual reset safety valve.

SURFACE COMBUSTION DIVISION
Midland-Ross Corporation
Toledo, Ohio 43601

By Jay Shah

Basic Furnace Metal Parts Furnace

Product Code

Order No. PC-1259

Auxiliary Equipment

Date August 28, 1974

Index No.

Quantity

Company Name U. S. Army Located at Edgewood Arsenal

Name and Title of Interested Official Richard Misiewicz, CPO

Assembly Drawing No. L-2 Modification of Order No.

Furnace Production

Part 155mm Projectile Shape Cylindrical Material Steel

Length		Width	Thick	Weight	PRODUCTION No./Hr.	PRODUCTION Lbs./Hr.	PRODUCTION Remarks
Max.	27"			84 lbs	40	3360	
Aver.							
Min.							

Remarks

Furnace Atmosphere Type Direct Fired CFH

Heating Cycle

Temp. Work Entering Furnace 100^{o} F Leaving 1000^{o} F

Time Work is to Remain in Zones: #1 Punch ~~XXXXXX~~ 60 mins Temp °F 100^{o} F

#2 Heat 15 mins 1000^{o} F (Furnace temp)

#2 Volatilization ~~XXXXX~~ 45 mins 700^{o} F

#3 Heat & Soak ~~XXXXX~~ 60 mins 1000^{o} F

Limits of Temperature if Given

Remarks

FURNACE CALCULATIONS

Show all data in determining length of zones and furnace on separate sheet or list reference to calculations below:

Length of the zones determined by the size of the munitions to be handled spray tank - 11½' long, 50 minimum 12' length required in a zone.

Zones	Furnace Construction: Length Door to Dr	Width WalltoWa	Height of Walls	Casing	Refractory IFB or FB, Insulation Type: Walls 2300IFB	Walls Ins.	Arch 2300IFB	Arch Ins.	Bottom	Bottom Ins.
~~Pre-Heat~~ #1	15'-0"	4'-0"	6'-10"	¼"						
~~Heat~~ #2	15'-7"	4'-0"	6'-5"	¼"	9"		9"		9"	
~~Soaking~~ #3	14'-6"	4'-0"	5'-7"	¼"	9"		9"		9"	
Cooling										
Doors	5'-6"	5'			Mechanism Roller Hearth/Tray					

(2-69)

Order No. ______

Conveying Medium

Type Roller (Boxes, Rollers, Conveyor) 39" IN/IN Collars effective width & length ______

Material ASTM297-HK Size 6" Dia. Weight ______ Work/Box in Lbs. 5466

Conveyor Load/Ft.^{2} 250 lbs. Roller Load each 883 lbs. C.L. to C.L. 15"

Table L'th-Chg. ______ Dis-chg ______ Hearth to Sprg. ______ Eff. Ht'h. ______ Floor to work level ______

Drive Mechanism

Brief Description Chain and Sprocket Roller drive, each chamber to have individual clutched drive.

Load Moved ______ Friction "K" ______ Stroke ______

Speed Ft./Min. 30 Time Interval 1 to 4 hours

Hydraulic Design Press. at Actuator 1500 PSI. ______ Hydraulic Fluid Mineral oil

Auxilliary Material Handling Equip. ______

Pyrometer Equipment

Current Available: 110 Volts AC/DC 60 Cycles

Item	Reqd.	Description
Make		
Ind. Control	2	
Rec. Control	3	
Lead Wire	400 ft	
Thermocouple	10	Type K in protection tubes
		Suitable for HCl, SO_2 atmosphere
Valve	4	Motor Control Valves
Valve	4	N. O. Solenoid Valves
Valve		

Safety Aid Equipment

SC ______ FM ______ FIA ______

Recirculating Fan

None Required

Combustion Blower

Air required cfm. 818 CFM at 16 oz. press

Supply 2 Blowers rated at 935 CFM each and 20 oz. to have adequate supply/or 5000 ft. elevation

Electric Motors Required

Power Available: 460 Volts AC/DC 60 CYCLES 3 PHASE

No. Required	1					
Location						
H.P.	2					
R.P.M.	1800					

UTILITY REQUIREMENTS:

Fuel: Type No. 2 fuel oil Supply Pressure 400 psig Max. Flow Req'd. 25 gpH

Water: Supply Temp. 80° Supply Pressure 30 psig Max. Flow Req'd. 1 gpm @ 10 °F Temp. Rise

Power Req'd.: (Max. Connected) ______ KW

Compressed Air: Supply Pressure ______ Max. Flow ______

-69) Piping S.C. [X] Customer [ ] Wiring S.C. [X] Customer [ ]

HEAT LOSS AT 1000 °F.								
Part of Furnace	Type	No.	Length	Width	Total Area	Radiat. Factor	Corr. Factor	Net BTU/Hr.
Sidewall	9" IFB	2	15'	8'	240	240		57,600
Endwall								
Arch	9" IFB	1	15'	6'	90	240		21,600
Bottom	9" IFB	1	15'	5'-6"	82.5	240		19,800
Door	6" IFB	1	5'-6"	5'	27.5	350		9,600
Burner Slot	B. B.	8	0'-5"	0'-5"	1.4	7656		10,600
Roller Slot Loss	B. B.	30	3" Ø		1.5	7656		11,300
Water Cooled Door	5 gpm	1				10' rise		25,000
							Total	155,500

Probable Flue Temp 1100 °F. (Direct Fired Only)

Avail. Heat = 68% @ 1100 °F, 0 % XA — X

At 100 °F. Items to be Heated		Pounds Per Hour	Heat Content		Net BTU/Hr.	Remarks
Work	450° F	3360	45		151,200	As only 15 minutes are allowed for heat-up, the total heat for work etc. will be 1,045,000
Container	450° F	1000	45		45,000	
Conveyor	———					
Mustard	450° F	500	130		65,000	
				Total Heat For Work, Etc.	261,200	
					Total Heat For Zone	1,200,000

BURNER SELECTION:

$$\text{Heat Input} = \frac{1,200,000}{0.68} = 1,765,000 \text{ Btu/hr.}$$

$$\text{Oil Consumption} = \frac{1,765,000}{138,000} = 12.8 \text{ gph}$$

Design capacity = 12.8 X 1.25 = 16 gph

Use 8 Burners with 2 gph oil rate

B.T.U. Release/Ft.^{2} Internal Area.

(2-69)

HEAT BALANCE CALCULATION (Use One Page Per Zone) #2 Order No. ____________

HEAT LOSS AT ______ °F.								
Part of Furnace	Type	No.	Length	Width	Total Area	Radiat. Factor	Corr. Factor	Net BTU/Hr.
Sidewall	9" IFB	2	15'	8'	240	150		36,000
Endwall								
Arch	9" IFB	1	15'	6'	90	150		13,500
Bottom	9" IFB	1	15'	5'6"	82.5	150		12,400
Door	6" IFB	1	5'6"	5'	27.5	220		6,000
Burner Slot	B.B.	8	0'5"	0'5"	1.4	2975		4,200
Roller Slot Loss	B.B.	30	3" Ø		1.5	2975		4,500
Water Cooled Door	5 gpm	1				7°F Rise		17,500

Probable Flue Temp ___800___ °F. (Direct Fired Only) Steam tempered flame with steam equivalent to 100% excess air (This (steam) will amount to 50% steam by vol.)

Avail. Heat = ___70%___ @ ___800___ °F, ___50___ % XA

Total	94,100
	X

At / Items to be Heated		450 °F.	Pounds Per Hour	Heat Content		Net BTU/Hr.	Remarks
Work		450°F	3360	0		---	As only 45 minutes are allowed for evaporation, Total heat for work etc = 113,300
Container		450°F	1000	0		---	
Conveyor							
Mustard Evap.		450°F	500	170		85,000	
					Total Heat For Work, Etc.	85,000	
					Total Heat For Zone		207,400

BURNER SELECTION:

$$\text{Heat Input} = \frac{207,400}{0.7} = 296,000 \text{ Btu/hr.}$$

$$\text{Oil consumption} = \frac{296,000}{138,000} = 2.15 \text{ gph}$$

As we have 8 burners in zone #2 with total capacity of 16 gph, we need a turn down capacity of 7.45

Steam rate = 75 lbs/hr

B.T.U. Release/Ft.^{2} Internal Area.

(2-69)

HEAT LOSS AT 1000 °F.

Part of Furnace	Type	No.	Length	Width	Total Area	Radiat. Factor	Corr. Factor	Net BTU/Hr.
Sidewall	9" IFB	2	15'	7'	210	240		50,400
Endwall								
Arch	9" IFB	1	15'	6'	90	240		21,600
Bottom	9" IFB	1	15'	5'6"	82.5	240		19,800
Door	6" IFB	1	5'6"	5'	27.5	350		9,600
Burner Slot	B.B.	4	0'5"	0'5"	0.7	7656		5,300
Roller Slot Loss	B.B.	30	3" Ø		1.5	7656		11,300
Water Cool								

Probable Flue Temp 1100 °F. (Direct Fired Only) Total 118,000

Avail. Heat = 50% @ 1100 °F, 100 % XA X

Items to be Heated At 450 °F.		Pounds Per Hour	Heat Content		Net BTU/Hr.	Remarks
Work	1000°F	3360	80		268,800	The work etc. is to be heated to 1000°F in ½ hour and then soak for ½, so total heat for work etc is
Container	1000°F	1000	80		80,000	
Conveyor						
				Total Heat For Work, Etc.	348,800	697,600
					Total Heat For Zone	815,600

BURNER SELECTION:

$$\text{Heat Input} = \frac{815{,}600}{0.5} = 1{,}631{,}200 \text{ Btu/hr.}$$

$$\text{Oil Consumption} = \frac{1{,}631{,}200}{138{,}000} = 11.8 \text{ gph}$$

$$\text{Design capacity} = 11.8 \times 1.25 = 14.8 \text{ gph}$$

Use 4 burners with 3.7 gph oil rate.

$$\text{During soak period, Heat input} = \frac{118{,}000}{0.5} = 236{,}000$$

$$\text{Oil Consumption} = \frac{236{,}000}{138{,}000} = 1.7 \text{ gph.}$$

$$\text{Turn down required} = 14.8 / 1.7 = 8.7$$

B.T.U. Release/Ft.^{2} Internal Area.

-69)

Order No. [illegible]

Burner Equipment Description:

Volatilization Zone - (8) 5" Sq. Tunnel, TRE Model No. 2070 O.E.

Burnout Zone - (4) 6 3/4" Sq. Tunnel, TRE Model No. 3011 O.E.

Oil ~~Xxx~~ Press @ Br.: 400 psig   Air Press @ Br.: 16 osi

Control Description:

Burner Capacity Summary:

Zone No.	Location U.F., O.F., E.F., Etc.	No. Of Brs.	Br. Size	Burner Oil ~~Xxx~~ Flow (~~Xxx~~) gph	Burner Air Flow (Scfm)	Zone Gas Flow (Scfh)	Zone Air Flow (Scfm)
#2		8	5"	2	50	24,000	400
#3		4	6 3/4"	3.7	90	42,600	710
Pilots							
Total							1110

Combustion Air Blower Sizing: PFB	440
AFB	290
+ Air For Fume Eductors, Cooling, Etc.	
Total Air Req'd.	1840
Min. Combustion Air Blower Rating	

Basis For Combustion Calculations

Fuel Oil #2, 138,000 BTU/~~Xx~~ gal. 0% in #2 / 100% in #2 % XA

Entrainment Ratio ______ (R.T.'s Only) 25% in PFB / 25% in AFB

C. Fume Burners

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the primary fume burner (PFB) and auxiliary fume burner (AFB) as specified herein.

b. The fume burner subassemblies shall be erected by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The fume burners will be installed within a shrouded area which is housed within a protective enclosure. Ambient conditions within the shrouded area will range from 50 F during extended shutdown periods up to 200 F during operating periods.

d. The fume burner subassemblies shall be transportable by railroad flat car. Flanged subassembly breakdown shall be approximately as shown on the Concept Design Drawing, sheet L-41. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

e. The unit shall be shop tested prior to shipment to the installation site. Testing will consist principally of firing the primary and auxiliary fume ignition burners. The test fuel shall be No. 2 fuel oil.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessi-

bility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Description

a. Agent fumes from the metal parts furnace (MPF) punching chamber and the volatilization chamber will be incinerated in an oil fired, horizontal, primary fume burner (PFB). This fume burner will be built generally to follow the concept design as shown on Drawing Sheet L-41. This fume burner shall have oil burners firing into a hot refractory lined chamber which serves as an ignition source for the mixture of agent fumes and combustion air.

b. Combustion products from the PFB and the MPF will be afterburned in an oil fired, horizontal auxiliary fume burner (AFB). This auxiliary burner will be built generally to follow the concept design as shown on Drawing Sheet L-41. An oil fired ignition burner shall be provided as an ignition source. Nominal afterburning temperature will be 1600 F.

c. Dimensions

1) Primary Burner

Length	7'-0"
Diameter at flange	5'-0"
Fume inlet diameter	1'-6"
Air inlet diameter	1'-4"

2) Primary Residence Chamber

Length	24'-0"
Outside diameter	5'-6"
Inside diameter	4'-0"
Volume, ft^3	300

3) Auxiliary Residence Chamber

Length	26'-0"
Outside diameter	5'-6"
Inside diameter	4'-0"
Volume, ft^3	300

6. Components

a. Casing

The casing will be rolled 1/4" carbon steel plate.

b. Refractory

Refractory lining will consist of 4 1/2" of 2600 F insulating firebrick on the hot face, backed by 4 1/2" of 2000 F insulating firebrick.

c. Burners (Primary)

There will be two (2) ignition burners, each rated at 1.05 MM Btu per hour on No. 2 fuel oil. Each burner will be direct spark ignited. Each burner will require 13,200 scfh combustion air.

d. Burner (Auxiliary)

The burner will be a 1.4 MM Btu/hour, No. 2 fuel oil fired, direct spark ignited unit. It will require 19,200 scfh combustion air.

e. Combustion Air

Combustion air for the ignition burners will be furnished from separate blowers furnished by others. Combustion air for the fume burner will be furnished from separate prime Contractor furnished fans. Available pressure and flow rates will be as follows:

Primary ignition burners . . . . . 440 acfm @ 16 osi
Auxiliary ignition burner . . . . . 320 acfm @ 16 osi
Primary fume burner . . . . 7500 acfm @ 8" w.c.

f. Safety Aids

The burners will be complete with ultraviolet flame scanners, interlocked to shut down in the event of flame failure. Hi-limit temperature control low temperature interlock are included, and flame scanner override when the temperature is above 1400 F.

A NEMA IV combustion control panel will be furnished with the fume burner assembly.

g. Controls

Automatic proportioning temperature control will increase the air from the combustion air fan to pace the input of fumes from the furnace. Fuel oil flow will be modulated to the auxiliary fume burner.

Operating temperature will be continuously recorded.

Process controls and instrumentation will be furnished by the Instrumentation Subcontractor under a separate sub-contract.

7. Ratings

a. Primary (PFB)

1) Mustard Filled

Operates as a rich fume incinerator. Ratings will be as follows:

	Rated Condition	Design
Temperature, ^{o}F	1600	2300
Mustard vapor, lbs/hr	1035	1294
MM Btu/hr	8.7	10.9
Combustion air, scfm	4140	5175
Auxiliary fuel, gph	4	5
Startup fuel, gph	15	15
Burner air, scfh	26,400	26,400

2) Drained

Operates as a lean fume incinerator. Auxiliary fuel is required to raise the gas temperature from 1000 F leaving the furnace to 1450 F leaving the fume burner. The operation will require a maximum of 20 gph of fuel oil for startup and approximately 4 gph for normal operation.

b. Auxiliary (AFB)

Operates as a normal fume incinerator burner, requiring 500,000 Btu/hour of auxiliary fuel input for normal operation. Ratings are as follows:

	Rated Condition	Design
Temperature, ^{o}F	1600	2300
Flue gas flow, scfm	5350	6700
MM Btu/hour input	7	8.8
Burner air, scfh	19,200	19,200
Auxiliary fuel, gph	5	6.25
Startup fuel, gph	10	10

D. Air Pollution Control

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the air pollution control equipment as specified herein.

b. The air pollution control subassemblies shall be erected by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The air pollution control equipment will be installed within a protective enclosure. Ambient conditions within the enclosed area will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods.

d. The air pollution control subassemblies shall be transportable by railroad flat car. Flanged subassembly breakdown shall be approximately as shown on the Concept Design Drawings. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

e. Concept Design Drawings are included as part of this specification. These include Exxon Research Drawings numbered 1722-1-A through 1722-11-A.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or

part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Design Specification

The design specification, prepared by Exxon Research and Engineering Company is hereby incorporated into the specifications.

DESIGN SPECIFICATION

COVERING

AIR POLLUTION CONTROL SYSTEM

FOR

METAL PARTS FURNACE

a. Scope of Specification

This specification covers the process design of the Air Pollution Control System for the Metal Parts Furnace section of the Chemical Agents Munitions Disposal System.

Major equipment included in this specification are the gas quench tower, venturi scrubber, scrubbing tower, reheat burner, exhaust blower, stack, caustic tank, product retention tanks, salt dryer feed tank, and associated pumps and instrumentation. Specifications for the salt dryers and associated components are not included.

This specification was prepared under Surface Combustion purchase order No. D66219-0, a subcontract under Army Contract No. DAAA15-74-C-0092.

b. Design Basis

The Air Pollution Control System is designed for automatic and continuous removal of gaseous and particulate pollutants from the Metal Parts Furnace and Afterburner. The degree of gaseous and particulate removal is designed to meet or surpass the required emissions standards.

The system is designed to have no liquid effluents, and will minimize water consumption while maintaining a 20-25 wt.% salt concentration feed to the salt dryers. Three four-hour hold-up tanks are provided to permit isolation, sampling, analysis, and certification of the salt solution before routing to the salt dryer. Caustic addition and pump-around agitation are provided to reduce residual agent concentration to the required levels.

Table 3 summarizes the gas analysis and flow conditions at the interface between the Metal Parts Furnace Afterburner and the Air Pollution Control System as provided by Midland-Ross.

The system emission standards and design goals are summarized in Table 4.

TABLE 3

FUME BURNER EXHAUST

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

	Ton Container with HD	M-104 Projectile with HD	M-426 Projectile with GB	M-426 Projectile with VX
Flow SCFM (dry)				
Volatilization	2755	3553	2000	2000
Rated	4133	5330	2000	2000
Design	5200	6700	2500	2500
Agent Input (lb/hr)				
Production Rate	425	468	17.4	17.4
Volatilization Rate	540	690	20	20
Rated Condition	810	1035	30	30
Gas Composition (dry)				
Per cent O_2	14.6	13.92	11.1	11.1
N_2	78.68	79.4	82.09	82.09
CO_2	4.20	4.22	6.7	6.7
SO_2	0.84	0.82	--	--
HCl	1.68	1.64	--	--
HF	--	--	0.073	--
P_2O_5	--	--	0.037	0.018
NO_x	--	--	--	0.037
Mustard	8.4×10^{-9}	8.2×10^{-9}	--	--
GB	--	--	7.3×10^{-10}	--
VX	--	--	--	3.7×10^{-10}
Temperature °F	1600	1600	1600	1600
Pressure psia	12	12	12	12
Moisture %	4.65	4.68	8.8	8.8
Dew Point °F	90	90	113	113
Particulate Loading	------------ assume 1 grain/std cu ft ------------			

TABLE 4

EMISSION STANDARDS AND DESIGN GOALS

Air Quality Standards for Stack Emissions

Emission	Standard
SO_x as SO_2	500 ppm (by volume) or 80% removal of input sulfur whichever is more stringent
Particulates	Based on process feed rate $E = 3.59\ P^{0.62}$ where E = emission rate (lb/hr) P = processing rate (tons/hr) approximately equivalent to 0.1 grain/std cu ft
Visible Opacity	less than 20% opacity
Agent Mustard	0.03 mg/am^3 (1 hr average)
Agent GB	3×10^{-4} mg/am^3 (2 hr average)
Agent VX	3×10^{-5} mg/am^3 (2 hr average)

System Liquids before Drying

Agent	Standard
Mustard	2 ppm
GB	5×10^{-8} gram/ml (enzyme test)
VX	5×10^{-8} gram/ml (enzyme test)

Water Quality Standards

No liquid effluent

Additional Emission Limit Design Goals

Emission	Goal
Inorganic phosphate as H_3PO_4	0.14 lb/min
Inorganic fluorides as HF	0.007 lb/min
Total acidity as HCl	0.03 lb/min

The Air Pollution Control System is designed to remove particulates, gaseous pollutants, and mists from the afterburner flue gas. Particulate removal is accomplished predominantly in the quench tower and venturi scrubber with minor additional removal in the scrubbing tower. Readily scrubbed gaseous pollutants will be largely removed in the quench tower and venturi, while those requiring contact time will be removed in the scrubbing tower packed section. The bulk of the fumes will also be removed in the scrubbing tower packed section, the remainder being eliminated by the scrubbing tower demister section.

Design considerations for each of the major components are as follows:

Quench Tower An upflow gas, countercurrent quench tower was selected to assure achieving at least 90% saturation of the afterburner flue gas before entering the venturi scrubber. Near saturation is necessary in order to avoid loss in particulate scrubbing efficiency due to vaporization within the venturi itself. The alternative downflow gas quench chamber above the venturi was ruled out due to the following:

- The chamber would approximate the present quench tower in size, thus requiring excessive headroom and overhead supports.
- High pressure (approximately 500 psig) nozzles with poor turn-down characteristics would be required.
- The approximately 25% excess water required would dilute the product salt concentration.

The quench tower achieves near saturation with large ported nozzles operating at low nozzle pressure by providing a large amount of excess quench liquor via a sump and pump-around approach. The quench liquor is comprised of quench brine from the scrubbing tower sump plus fresh quench water make-up (demineralized well water) with the excess quench brine returned to the scrubbing tower on level control. This approach is chosen over an independent quench tower pump-around so that the salt and particulate concentration in the quench tower sump can be maintained at an acceptable level without requiring a purge stream which would add to the salt dryer load.

The 4 ft. quench tower diameter is selected so that, at design condition velocity, entrainment will be approximately 3% of the entering quench water rate. This is very nearly equal to the additional water required to attain full saturation. The quench liquor rate is set so that, to achieve 90% of saturation at design conditions, the tower height requirement is compatible with the elevation of the venturi scrubber.

The desired rate of demineralized well water make-up to the quench tower is that amount required to fully saturate the incoming hot flue gas. With the use of excess liquor via pump-around, however, the make-up rate cannot be set on quench zone temperature control without causing wide swings in product salt concentration as the flue gas rate varies. For this reason, the make-up is shown on flow control, and its set point is cascaded from the fume burner air control. In this way, the quench water make-up will be maintained proportional to the quenching heat load as long as the afterburner exit temperature is reasonably constant.

For flexibility, the make-up rate may alternatively be controlled to a manually selected set point, but this mode requires a pre-knowledge of the average flue gas rate over a given operating period. For this case, a density indicator for salt concentration monitoring is provided at the scrubbing tower sump to guide the operator in setting the quench water make-up rate. Additionally, both the make-up flow controller and the quench rate flow controller are equipped with remote set point capability to make changing to other control modes possible if desired.

Venturi Scrubber The venturi scrubber is sized to provide high efficiency particulate scrubbing at the design rate, and is equipped with a variable throat which is modulated on constant differential pressure control to maintain this high efficiency at turndown conditions. At the selected 20 inches of water differential pressure and 20 GPM scrubbing water per 1000 ACFM entering gas, Ducon Co. has estimated an efficiency of 99.9% at 5 microns particle size and 99.3% at 2 microns. Figure 1 illustrates a somewhat better performance may be expected based on ER&E calculations.

The venturi scrubber is equipped with large, cyclonic-inlet, scrubbing water ports with no nozzles, and is not conducive to plugging.

Since 90% saturated gas will enter at approximately 300°F, a rubber lined throat is not feasible. Instead, the throat section will be fabricated of Hastelloy and will be flanged for ease of removal. A side access port is provided for throat inspected.

Scrubbing Tower The packed section of the scrubbing tower is designed to provide high efficiency SO_2 removal at the design rate. The selected 10 ft. bed height of 1 inch pall rings with 10 GPM/FT^2 clean scrubbing liquor will provide at least 95% SO_2 removal.

Alloy pall rings are specified because of their long term durability and their wetting characteristics which enhance high efficiency. As a cost reduction measure, polypropylene pall rings can be substituted with a minor, undefinable loss in efficiency as long as it is recognized that replacement packing may be required if the tower temperature exceeds 300°F during upset conditions. Carbon or carbate pall rings provide a third alternative which offers no wetting or temperature concerns. These are, however, subject to breakage such as would be expected with ceramic and are not an advisable selection unless the initial cost differential is great.

The 6 ft. tower diameter is specified so that, at the design rate, the packed section will operate at 85% of flooding velocity and will exhibit a pressure drop of 12 inches of water. The packed section will maintain high SO_2 scrubbing efficiency down to approximately 20% of flooding velocity and is, therefore, capable of greater than 4 to 1 turndown. This satisfies all conditions under which SO_2 will be present in concentrations exceeding system requirements. The tower diameter cannot be reduced to provide greater turndown capability since this would increase the packed section pressure drop to 18 inches of water at design conditions.

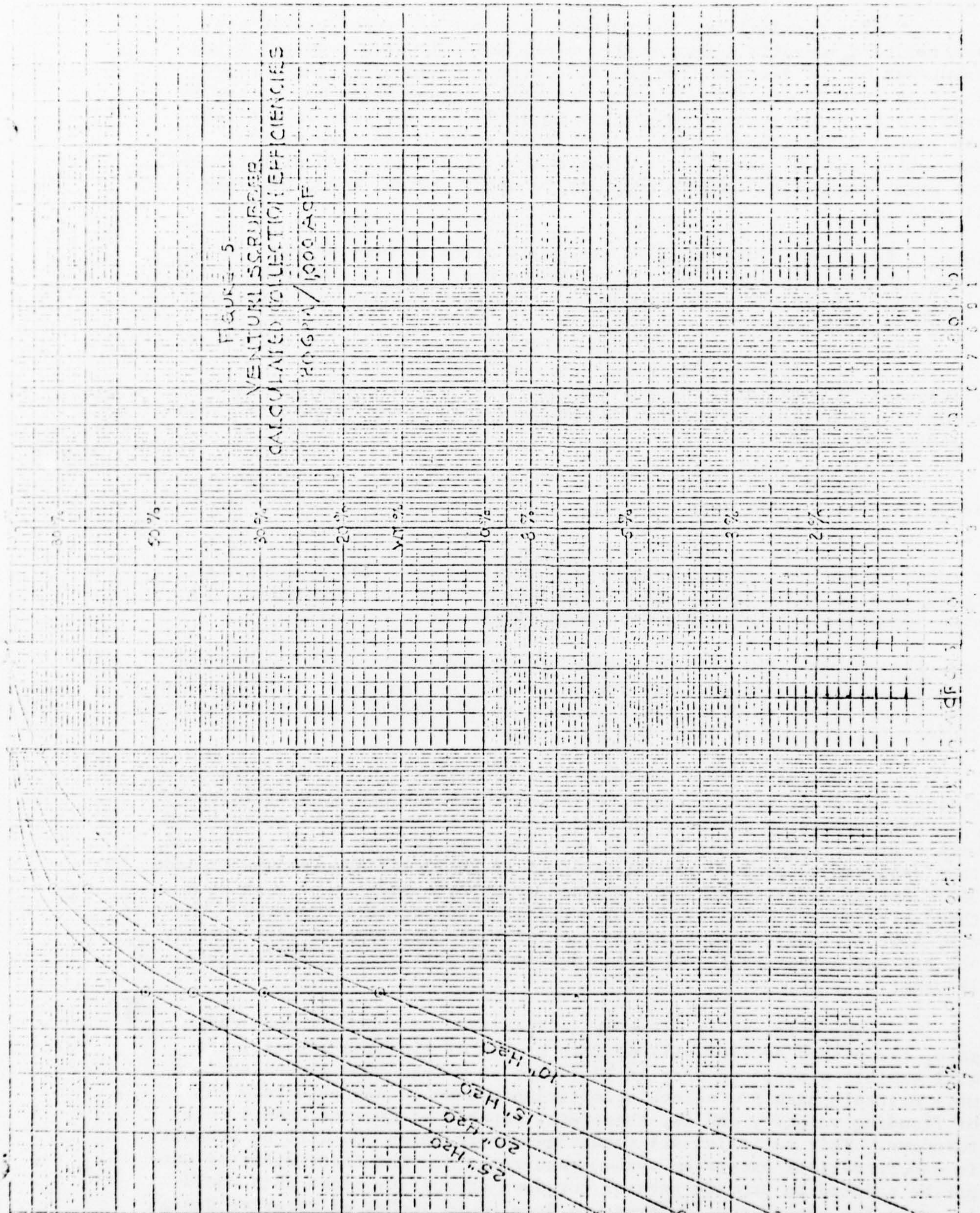
FIGURE 5
VENTURI SCRUBBER
CALCULATED COLLECTION EFFICIENCIES
20 GPM/1000 ACF
10" H2O
15" H2O
20" H2O
25" H2O

METAL PARTS FURNACE
CALCULATED VENTURI SCRUBBER EFFICIENCIES
FOR
BASIS PARTICLE LOADING

Particle Size Microns	Entering Lb/Hr	Collection Efficiency	Collected Lb/Hr
> 1.0	47.20	100.0%	47.20
0.6 - 1.0	5.37	98.4%	5.28
0.4 - 0.6	3.23	81.1%	2.62
0.2 - 0.4	3.17	41.2%	1.31
0.0 - 0.2	2.01	3.8%	0.08
	60.98		56.49

Overall Efficiency = (56.49/60.98) x 100 = 92.6%

The gas inlet to the scrubbing tower is tangential with appropriate baffling so as to avoid plugging the packed section due to particulate laden entrainment. A tilted chimney tray with bypass wash and bypass purge are designed to minimize the particulate PPM level in the clean liquor, and the weir trough distributor is suited to much higher particulate levels than are anticipated.

Phosphoric acid mist removal will be accomplished with five 2 ft. diameter by 6 ft. tall Brink high efficiency (HE) demisters with 2 inch thick, 95% efficiency polypropylene packing. These demisters will exhibit a pressure drop of 10 inches of water at the M-426 projectile design rate which is the most stringent condition under which P_2O_5 will be present in the afterburner flue gas. At reduced rates, they will exhibit a somewhat higher efficiency. A manually removable plate is provided in the demister support sheet to allow bypassing the demisters at the higher rates when phosphoric acid mist will not be present. A standard open density crinkled wire mesh screen (cwms) is provided for entrainment removal when this bypass plate is open.

The Brink demisters are removable and can be readily repacked with higher efficiency fiberglass if operating experience indicates higher pressure drops are available or if demisting will only be necessary at further reduced flow rates.

The demisters were initially specified to be polypropylene since fiberglass cannot withstand a caustic environment, and the specifications were selected to effect the best compromise among size, pressure drop, and efficiency based on the options originally offered by Brink. However, Brink subsequently indicated that these options are only available with fiberglass packing and that polypropylene packing is only manufactured in a 3 inch thick, 99% efficiency version. Thus, polypropylene demisters would require considerable additional area to handle the flow at the available pressure drop.

Brink has indicated that the standard polypropylene demister design is the result of mechanical strength limitations; i.e., polypropylene will cold flow and allow gas bypassing if not densely packed and carefully supported. Brink has offered to fabricate a 2 inch thick polypropylene demister for piloting purposes, but the limited potential savings in demister size presents little incentive to pursue this possibility.

Clearly, revisions will be required to the demister section design unless piloting can demonstrate that fiberglass units will present an adequate life between replacements. The alternatives are:

1. Increase the scrubbing tower height by approximately 12 ft. to accommodate five 18 ft. tall polypropylene demisters, if possible.

2. Increase the scrubbing tower demister section diameter to approximately 11 ft. to accommodate approximately fifteen demisters of the same 6 ft. height presently specified.

3. Effect a compromise between alternatives 1 and 2 above.

4. Install a separate demister chamber at grade sized for the polypropylene demisters and with associated pump, piping and level control systems.

5. Evaluate and/or pilot alternate demisting products such as the Water Web Mesh made by Heat Systems - Ultrasonics, Inc., of Plainview, N.Y.

Also, the option of eliminating the demisters should not be disregarded. The Army found these demisters necessary to avoid excessive phosphoric acid mist carryover when handling the flue gas from a bulk agent disposal system. When handling drained munitions, however, the phosphorous pentoxide concentrations are considerably reduced. The production of H_3PO_4 in the Metal Parts Furnace if all the phosphorous were converted would be 0.47 lb./min. This would require only 70% scrubbing efficiency to meet the Army's emission limit design goal of 0.14 lb./min. of inorganic phosphates as H_3PO_4 in the worst case. However, according to Brink, the threshold of visibility for P_2O_5 is approximately 0.4 mg/ACF which is equivalent to about 0.0078 lb. H_3PO_4/min. This represents a more stringent limitation, requiring an overall efficiency of 98% which may not be attainable without demisters. In either case, the reheat burner will allow for additional dilution and dispersion time and further reduce the likelihood of visible emissions.

Elimination of the Brink demisters will significantly reduce the size and cost of the air pollution control systems. In the event they are deemed necessary at a later date, they can be added as a separate chamber at grade for little incremental cost over including them initially.

Mounting details for the scrubbing tower have not been considered since detailed plot plans and elevations were not included within the framework of this design. A minimum of approximately 4 ft. should be provided beneath the scrubbing tower purge outlet to allow for the purge pumps and associated piping.

Exhaust Blower The exhaust blower is sized to provide adequate static pressure at the design rate with the reheat burner at maximum firing. The selected backwardly inclined tip blade design offers the following advantages:

- The power requirement curve has a maximum, hence is non-overloading at high flow, low pressure.
- The pressure-capacity curve is conducive to stable operation.
- High efficiency - typically 65-80%.

Due to the high turndown requirement, the blower is equipped with inlet vanes with electrical positioner for remote turndown control. This positioner may be adjusted manually from the control module or on furnace module pressure control.

Reheat Burner The reheat burner is sized to avoid a visible steam plume from the stack at slightly lower than the specified 55°F/50% R.H. goal. All appropriate fail-safe interlocks are provided.

Stack The stack is 30 inches in diameter, constructed to provide a discharge port a minimum of 50 ft. above the ground, and is provided with sampling ports for emission monitoring.

Retention Tanks Three product hold-up tanks are provided to permit isolation, sampling, analysis, and certification of the salt solution before routing to the salt dryers. Each retention tank is sized for four hours' hold-up at 125% production rate with allowance for salt dilution to 20 wt.%.

Caustic addition and pump-around agitation are provided to reduce residual agent concentration to the required level. Each pump is sized to empty its tank in approximately one hour at the production rate, and, at 50% bypass, to provide thorough tank mixing also in approximately one hour. With these provisions, the three retention tanks will allow continuous uninterrupted operation of the scrubbing facilities even if one salt solution batch fails initial certification. Piping is provided to permit pumping directly from the retention tanks to the salt dryers if necessary.

The retention tank dimensions are selected to fit within the 20 ft. headroom available at their location within the building. Internal steam coils are provided to maintain the salt solution above its saturation temperature. Steam tracing is not specified for the brine piping. The design relies on continuous circulation to avoid salt precipitation, and the lines must be flushed in anticipation of extended shut-down periods. Based on solubility data,* a minimum brine line temperature of 85°F will assure no precipitation for up to 25 wt.% sodium carbonate solutions and up to 20 wt.% sodium sulfite solutions, which exceeds the worst case conditions.

Salt Dryer Feed Tank The salt dryer feed tank is sized for eight hours hold-up at 125% production rate with allowance for salt dilution to 20 wt.%. The feed tank is equipped with caustic addition and pump-around agitation so that it may serve as a retention tank if necessary. Its pump is identical to the retention tank product pumps and can empty the feed tank in approximately two hours. The flow rate from the feed tank to the salt dryer is set by a remote control valve which can receive its signal from the salt drier control system.

The salt dryer feed tank dimensions are also selected to suit the available 20 ft. headroom, and an internal steam coil is again provided.

Caustic Tank A caustic tank is provided as an interface supply between the main caustic supply source and the Air Pollution Control System. This tank is sized for approximately 5 hours' hold-up of 18 wt.% sodium hydroxide at 125% production rate. A remote block valve is provided at this tank inlet to automatically shut when the tank is filled.

The caustic tank dimensions are selected to suit both the available 20 ft. headroom and the available floor space for diking at its location within the building.

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* Solubilities of Inorganic and Organic Compounds," H. Stephen and T. Stephen, Pergamon Press, 1963.

Pumps All Air Pollution Control System pumps are sized for the design rate with excess capacity where needed for pump-around agitation. Discharge pressure capabilities are sufficient to allow for piping, orifice, and control valve pressure drops in addition to vertical head requirements.

Pumps handling particulate laden salt solution are of slurry construction and are equipped with externally flushed double mechanical seals.

Single seals, whether mechanical or packing, or self-flushed double seals are inadvisable for these applications without risk of poor seal life due to solids and/or salt deposits on the rubbing surfaces. Furthermore, these approaches represent significant sources of process fluid emission and would require special drainage provisions to handle the necessary but "uncertified" seal leakage.

A single seal with an externally flushed throat bearing could, if properly applied, provide adequate sealing performance and reliability without process fluid leakage, but would untenably result in process stream dilution at a rate of 0.5 to 5.0 GPM.

The quench brine pump (P-302) and slurry pump (P-304) may be combined as a single large unit with essentially no sacrifice in reliability. Since relatively little particulate settling is anticipated in the scrubbing tower sump, this unit may be further combined with the purge pump (P-301) as long as the capacity of the purge bypass regulator (P-011-CV) is not increased. It should be recognized that exercising the latter option will dictate using the high capacity pump for all shutdown pump-out operations.

Instrumentation The Air Pollution Control System is instrumented to insure fail-safe automated operation and prevent damage from occurring to the equipment. It is interlocked with the furnace and afterburner modules so that they cannot be activated unless specified alarmed parameters are within normal controlled ranges, and so that they will be automatically shut down at a safe time should specific alarms occur. In certain cases, a period after alarm to shutdown is provided to effect manual corrective action if possible.

Upon loss of commercial power, all instrumentation, specified pumps, and the exhaust blower at half speed will automatically shift to standby emergency power to assure safe handling of afterburner flue gas during the shutdown period.

O_2 and SO_2 analyzers and associated equipment are provided at the stack gas monitoring station. These are equipped with continuous recording and adjustable set point alarms coupled to alarms in the main control module. These alarms activate a furnace excursion control circuit but do not initiate shutdown. A refrigerated dryer is provided to minimize analyzer interference due to water vapor. Some improvement in SO_2 analyzer accuracy could be realized by using a Perma-Pure heatless dryer if dry air were made available.

Materials Materials of construction for the Air Pollution Control System are selected to provide a ten year life with essentially maintenance free operation.

As a cost reduction measure, carbon steel may be substituted for monel for the salt solution piping and valves. Depending on the frequency of operation with HCl in the afterburner flue gas and on the care given to maintaining proper pH levels, carbon steel could provide as much as a five year life but would require maintenance thereafter. All carbon steel welds in this application must be stress relieved by heat treatment in accordance with ANSI B31.3.

Emergency Shutdown System

1. The air pollution control system shall be interlocked with the furnace and afterburner modules so that they cannot be activated unless the air pollution control system is operating with all shutdown parameters in their normal controlled ranges.

2. The air pollution control system shall be interlocked with the furnace and afterburner modules so that they will be automatically shut down when the specified time after alarm to shut down has elapsed. The period after alarm to shut down provides operator time to manually effect corrective action if possible.

3. Upon loss of commercial power, all instrumentation, those pumps specified , and the exhaust blower at half speed shall automatically shift to emergency standby power.

4. The emergency quench tower overflow valve (R-021-BV) shall open full in the event of the high-high level alarm (L-002-HA) in the quench tower sump. Similarly, the emergency scrubbing tower overflow valve (R-022-BV) shall open full in the event of the high-high level alarm (L-005-HA) in the scrubbing tower sump. Both circuits shall be maintained active via emergency standby power upon loss of commercial power.

5. Control valves R-005-CV through R-011-CV and block valves R-016-BV through R-020-BV to de-energize automatically on high or low tank level alarm as tabulated

6. Except as tabulated above, shutdown of all air pollution control system components shall be manually initiated.

EMERGENCY ACTION

ALARM	PROBABLE CAUSE	CONSEQUENCE	ACTION	TIME
FLA F-001-RC	Partially plugged control valve.	Reduced venturi scrubbing efficiency.	Manually open bypass globe valve at site.	10 MIN
FLA F-002-RC	Partially plugged control valve.	Reduced tower scrubbing efficiency.	Manually open bypass globe valve at site.	10 MIN
FLA F-003-RC	Partially plugged control valve.	High quench zone temperature.	Manually open R-004-CV from control module.	NA - SEE T-001-HA
LHA L-001-RC	Plugged quench return pump suction.	Overfill quench tower-water to afterburner.	Manually reduce quench rate via F-001-RC. Manually purge suction line.	NA - SEE L-002-HA
LLA L-001-RC	Level control valve stuck open.	Empty quench tower-bypass gas.	Manually adjust control valve via controller. Manually operate valves at site.	NA - SEE L-003-LA
L-002-HA	Plugged quench return pump suction.	Overfill quench tower - water to afterburner.	Automatically shutdown furnace and afterburner. Automatically open R-021-BV.	0 MIN
L-003-LA	Level control valve stuck open.	Empty quench tower - bypass gas.	Automatically shutdown furnace and afterburner.	0 MIN
LHA L-004-RC	Plugged purge pump suction.	Overfill scrubbing tower.	Manually purge suction line.	NA - SEE L-005-HA
LLA L-004-RC	Level control valve stuck open.	Empty scrubbing tower - lose quench & slurry flows.	Manually adjust control valve via controller. Manually operate valves at site.	NA - SEE L-006-LA
L-005-HA	Plugged purge pump suction.	Overfill scrubbing tower.	Automatically shutdown furnace and afterburner.	0 MIN
L-006-LA	Level control valve stuck open.	Empty scrubbing tower - lose quench & slurry flows	Automatically shutdown furnace and afterburner. Automatically open R-022-BV.	0 MIN
LHA L-007-I	Caustic tank D-604 full.	Overfill tank.	Automatically shut R-020-BV.	NA
LLA L-007-I	Caustic tank D-604 near empty.	Loss of caustic scrubbing capability.	Manually open R-020-BV.	30 MIN
LHA L-008-I	Retention tank D-601 full.	Overfill tank.	Automatically shut R-016-BV.	NA
LLA L-008-I	Retention tank D-601 near empty.	Bypass gas.	Automatically shut R-005-CV and R-008-CV.	NA

EMERGENCY ACTION

ALARM	PROBABLY CAUSE	CONSEQUENCY	ACTION	TIME
LHA L-009-I	Retention tank D-602 full.	Overfill tank.	Automatically shut R-017-BV	NA
LLA L-009-I	Retention tank D-602 near empty.	Bypass gas.	Automatically shut R-006-CV and R-009-CV.	NA
LHA L-010-I	Retention tank D-603 full.	Overfill tank.	Automatically shut R-018-BV.	NA
LLA L-010-I	Retention tank D-603 near empty.	Bypass gas.	Automatically shut R-007-CV and R-010-CV.	NA
LHA L-011-I	Salt dryer feed tank full.	Overfill tank.	Automatically shut R-019-BV.	NA
LLA L-011-I	Salt dryer feed tank near empty.	Bypass gas.	Automatically shut R-011-CV.	NA
T-001-HA	Loss of quench water.	Exceed venturi temperature rating.	Automatically shutdown furnace and afterburner. Automatically open R-021-BV and the T-601 level control valve.	0 MIN
T-002-HA	Excessive reheat burner firing.	Exceed exhaust blower temperature rating.	Automatically deactivate reheat burner.	NA
PdHA P-001-dRC	Venturi throat improperly adjusted.	Pressurize furnace.	Automatically shutdown furnace and afterburner. Manually open throat via controller or at site.	0 MIN
PdLA P-001-dRC	Venturi throat improperly adjusted.	Reduced venturi scrubbing efficiency.	Manually adjust throat via controller or at site.	10 MIN
PdHA P-002-dI	Plugging of tower packed section.	Reduced scrubbing efficiency-pressurize furnace.	Manually open R-001-CV rinse-monitor-shutdown furnace and afterburner if dP becomes excessive.	NA
PdHA P-003-dI	Plugging of tower demister section.	Reduced demisting efficiency-pressurize furnace.	Manually open R-001-CV rinse-monitor-shutdown furnace and afterburner if dP becomes excessive.	NA
P-004-LA	Loss of caustic pump.	Loss of caustic scrubbing capability.	Manually switch to standby pump.	10 MIN
P-005-LA	Loss of slurry pump. Plugged suction line.	Loss of venturi scrubbing.	Manually switch to standby pump.	2 MIN

EMERGENCY ACTION

ALARM	PROBABLE CAUSE	CONSEQUENCY	ACTION	TIME
P-006-LA	Loss of purge pump.	Overfill tower.	Manually switch to standby pump.	NA - SEE
	Plugged suction line.		Manually purge suction line.	L-005-HA
P-007-LA	Loss of clean liquor pump.	Reduced tower scrub-	Manually switch to standby pump.	10 MIN
	Plugged suction line.	bing efficiency.	Manually open and close R-002-CV intermittently.	
P-008-LA	Loss of quench pump.	High quench zone	Manually switch to standby pump.	NA - SEE
	Plugged suction line.	temperature		T-001-HA
P-009-LA	Loss of quench return pump.	Overfill tower.	Manually switch to standby pump.	NA - SEE
	Plugged suction line.		Manually purge suction line.	L-002-HA
P-010-LA	Loss of pH sample pump.	Loss of pH control.	Manually switch to standby pump.	10 MIN
	Plugged suction line.			
pH HA pH-001-RC	Loss of pH control.	Excessive CO_2 scrubbing.	Manually adjust control valve via controller.	10 MIN
ph LA ph-001-RC	Loss of pH control.	Loss of caustic scrubbing capability.	Manually adjust control valve via controller.	10 MIN

TABLE [illegible]

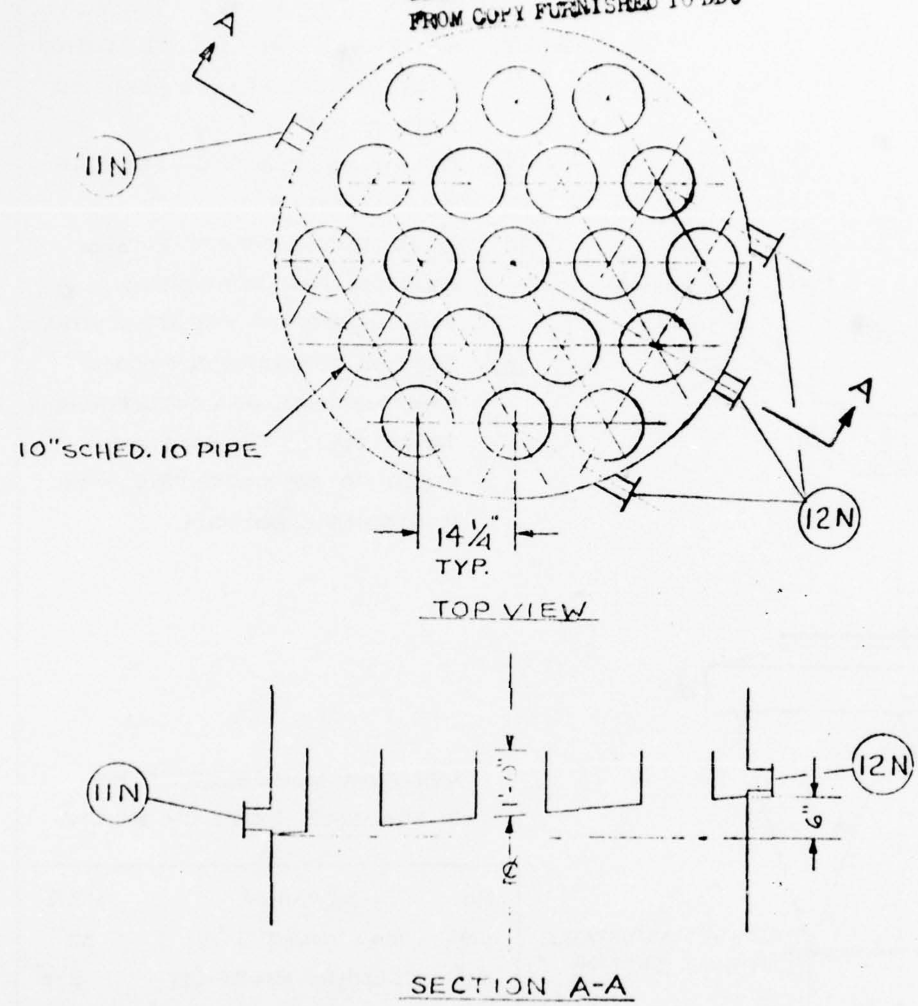
STREAM PROPERTIES

STREAM NUMBER	1	2	3	4	5	6
DESCRIPTION	QUENCH WATER	DEMISTER RINSE WATER	CAUSTIC	RETENTION TANK CAUSTIC ADDITION	CLEAN LIQUOR TO DISTRIBUTOR	CLEAN LIQUOR TO CHIMNEY TRAY
State	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid
Temperature, °F	90	90	90	90	155	155
Pressure, psig	40	40	27	27	26	26
Lbs/Hr	11,500	5,000	11,300	3,000	165,800	15,600
Lbs/Gal @ Cond.	8.3	8.3	10.0	10.0	10.4	10.4
Viscosity, Cp @ Cond.	1.0	1.0	2.7	2.7	1.2	1.2
Wt.% Solids	-	-	-	-	400 PPM	400 PPM

STREAM NUMBER	7	8	9	10	11	12
DESCRIPTION	CLEAN LIQUOR BYPASS	QUENCH BRINE	QUENCH BRINE RETURN	SLURRY	PRODUCT FROM TOWER	PRODUCT FROM TANKS
State	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid
Temperature, °F	155	155	160	155	155	150
Pressure, psig	26	27	22	30	26	26
Lbs/Hr	6,300	32,300	32,400	200,000	13,500	13,500
Lbs/Gal @ Cond.	10.4	10.4	10.4	10.4	10.4	10.4
Viscosity, Cp @ Cond.	1.2	1.2	1.2	1.2	1.2	1.2
Wt.% Solids	400 PPM	0.5	0.5	0.5	0.5	0.5

PROCESS VESSELS

INDEX	DRAWING
Quench Tower T-601	1722-7-D
Scrubbing Tower T-602	1722-6-D
Chimney Tray Details	1722-11-A
Venturi V-601	1722-8-D
Retention Tanks D-601, D-602, D-603	1722-3-A
Salt Dryer Feed Tank D-604	1722-4-A
Caustic Tank D-605	1722-5-A
Anti-Vortex Baffle Details	1722-9-A
Level/Pressure Tap Baffle	1722-14-A



19 PIPES TO BE EQUALLY DISTRIBUTED IN 60° TRIANGULAR PATTERN

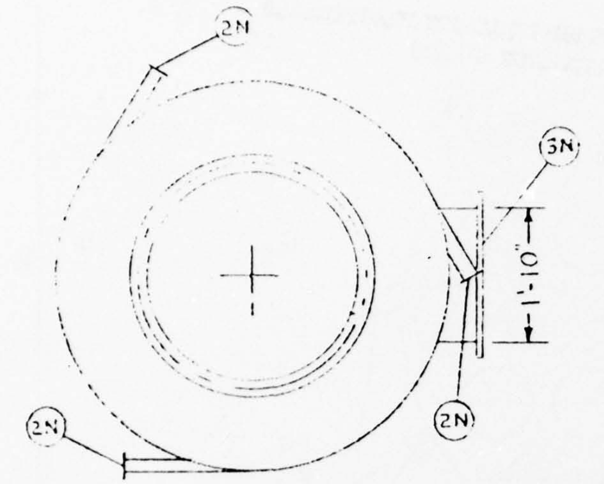
No.	SERVICE	SIZE
11 N	CLEAN LIQUOR OUTLET	6"
12N	CLEAN LIQUOR RETURN (3)	2"

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
SCRUBBING TOWER
CHIMNEY TRAY DETAILS

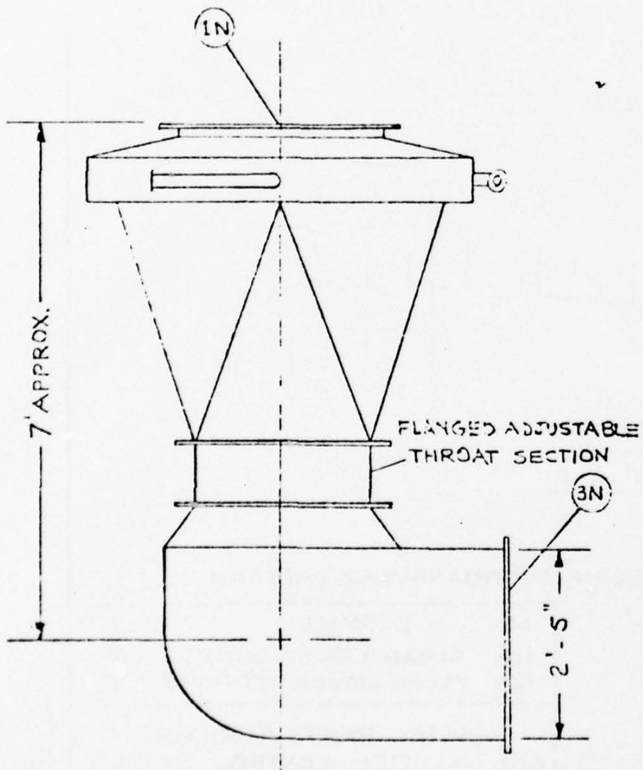
EXXON RESEARCH AND ENGINEERING Co.
MECHANICAL DIV.

E.C.VATH/R.M.B

DWG. No. 1722-11-A



PLAN



ELEVATION

NOTES:

1. DESIGN PRESSURE 14.9 PSIG
   DESIGN TEMPERATURE 500°F
2. MATERIALS - HASTELLOY C-276
3. PROVIDE SIDE ACCESS PORT FOR THROAT INSPECTION.
4. THROAT SECTION TO BE FLANGED AND REMOVABLE.
5. ADJUSTABLE THROAT TO BE EQUIPPED WITH ELECTRICAL POSITIONER FOR REMOTE CONTROL.
6. PROVIDE TRANSITION FROM RECTANGULAR GAS OUTLET ELBOW TO 24" DIA. TRANSITION PIECE TO BE ECCENTRIC, WITH HORIZONTAL BOTTOM.

VENTURI SCRUBBER TO BE DUCON SIZE 32/27 OR EQUIV.

No.	SERVICE	SIZE
1N	GAS INLET	32"
2N	SLURRY INLET (3)	2½"
3N	GAS OUTLET	PER DWG.

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
VENTURI SCRUBBER
V-601

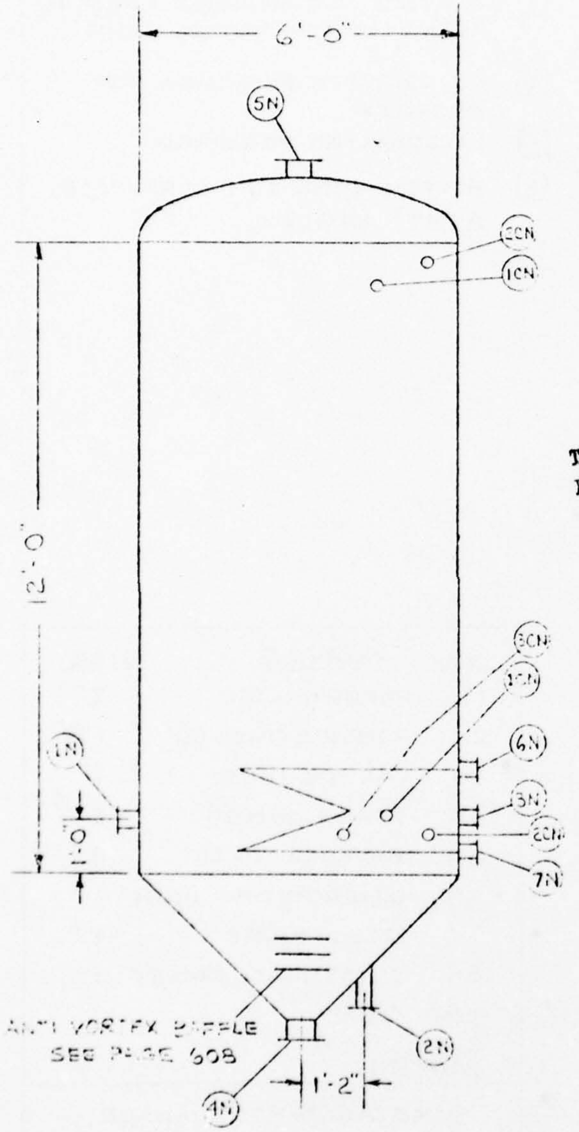
EXXON RESEARCH AND ENGINEERING Co.

E.C.VATH/R.W.B.

DWG. No. 1722-8-A

NOTES:

1. DESIGN PRESSURE: 14.9 PSIG
   DESIGN TEMPERATURE: 300° F
2. MATERIALS: CARBON STEEL
   WITH 1/8 MONEL CLADDING.
3. PROVIDE ONE MANHEAD MINIMUM
   ABOVE BOTTOM TANGENT LINE.
4. NO INSULATION REQUIRED.
5. NO DEMISTER REQUIRED.
6. BOTTOM CONE TO INCORPORATE
   A 45° ANGLE.
7. STEAM COIL TO BE 1" PIPE,
   1½ TURNS, 4' DIA.



No.	SERVICE	SIZE
1N	PURGE INLET	2"
2N	PURGE BYPASS	1½"
3N	CAUSTIC INLET	1"
4N	PURGE OUTLET	2½"
5N	BALANCE LINE	3"
6N	STEAM INLET	1"
7N	CONDENSATE OUTLET	1"
1CN	LI (2)	
2CN	LG (2)	
3CN	TI	

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
RETENTION TANKS
D-601, D-602, D-603

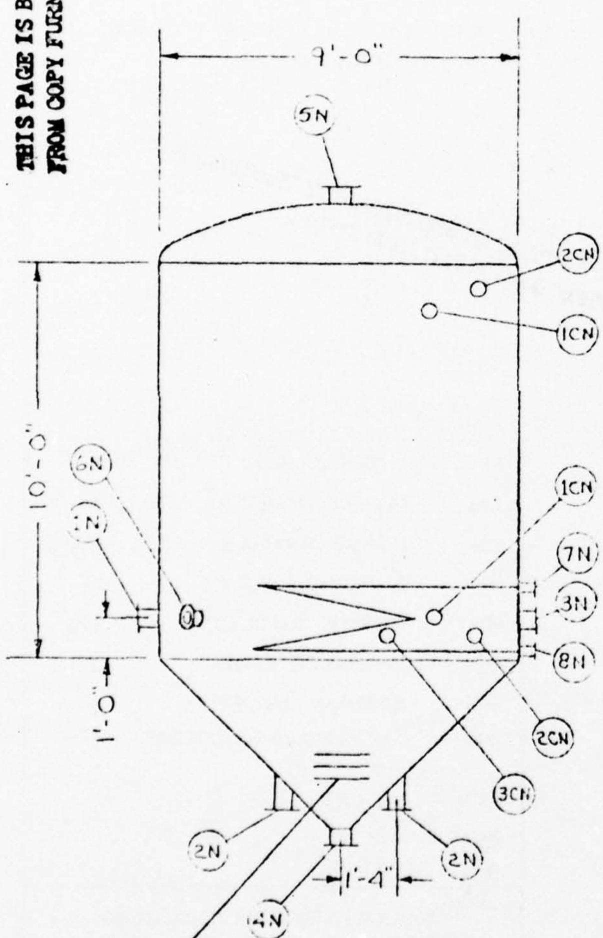
EXXON RESEARCH AND ENGINEERING Co.
MECHANICAL DIV

E.C.VATH / R.W.B

DWG. No. 1722-3-A

NOTES:

1. DESIGN PRESSURE: 14.9 PSIG
   DESIGN TEMPERATURE: 300°F
2. MATERIALS: CARBON STEEL WITH 1/8" MONEL CLADDING.
3. PROVIDE ONE MANHEAD MINIMUM ABOVE BOTTOM TANGENT LINE.
4. NO INSULATION REQUIRED FOR PROCESS.
5. NO DEMISTER REQUIRED.
6. BOTTOM CONE TO INCORPORATE A 45° ANGLE.



ANTI-VORTEX BAFFLE
SEE PAGE 608

No.	SERVICE	SIZE
1N	PURGE INLET	2"
2N	PURGE BYPASS (2)	1 1/2"
3N	CAUSTIC INLET	1"
4N	PURGE OUTLET	2 1/2"
5N	BALANCE LINE	3"
6N	DRYER RETURN INLET	2"
7N	STEAM INLET	1"
8N	CONDENSATE OUTLET	1"
1CN	LI (2)	
2CN	LG (2)	
3CN	TI	

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
SALT DRYER FEED TANK
D-604

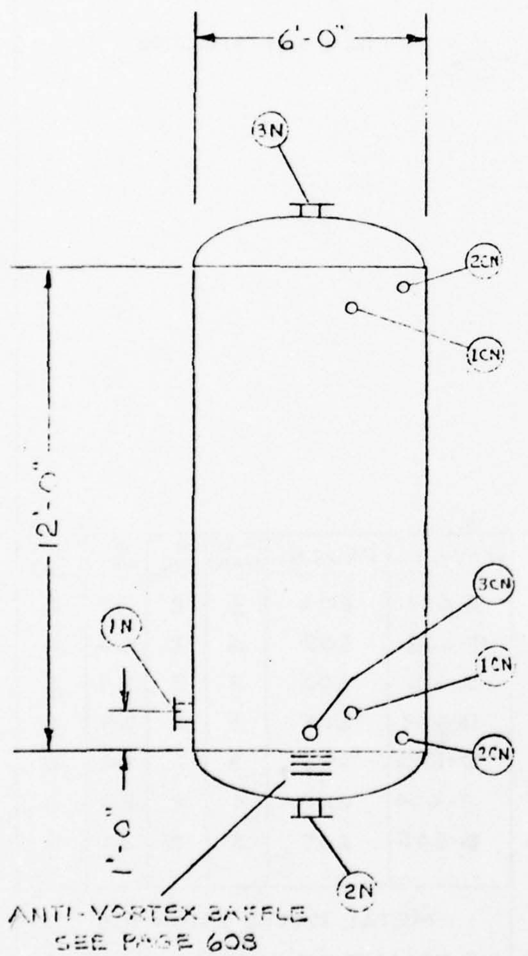
EXXON RESEARCH AND ENGINEERING Co.

E.C. VATH / R.W.B.

DWG. No. 1722-4-A

NOTES:

1. DESIGN PRESSURE: 14.9 PSIG
   DESIGN TEMPERATURE: 150°F
2. MATERIALS: CARBON STEEL-1/8" CA
3. PROVIDE ONE MANHEAD MINIMUM ABOVE BOTTOM TANGENT LINE.
4. NO INSULATION REQUIRED FOR PROCESS.
5. NO DEMISTER REQUIRED.



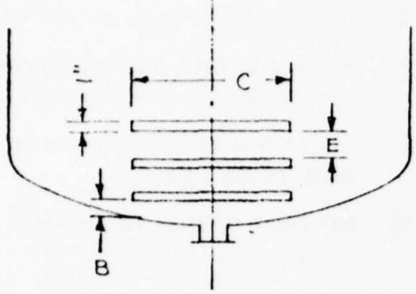
No.	SERVICE	SIZE
1N	CAUSTIC INLET	3"
2N	CAUSTIC OUTLET	2"
3N	VENT	3"
1CN	LI (2)	
2CN	LG (2)	
3CN	TI	

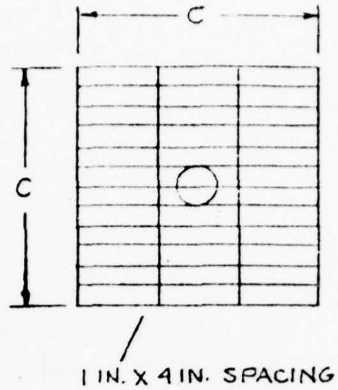
METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
CAUSTIC TANK
D-605

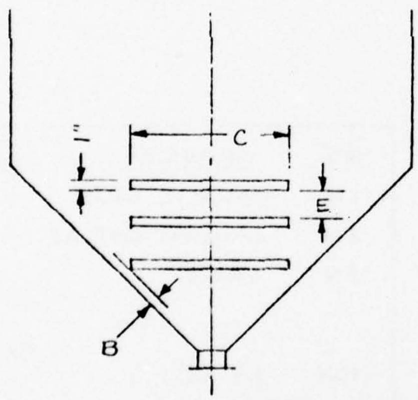
EXXON RESEARCH AND ENGINEERING Co.
MECHANICAL DIV.

E.C.VATH/RWB

DWG No. 1722-5-A







VESSEL No.	PAGE No.	No. OF GRATES	B (IN)	C (IN)	E (IN)
T-601	601	3	2	20	6
T-602	602	4	2	24	6
D-601	605	3	2	24	6
D-602	605	3	2	24	6
D-603	605	3	2	24	6
D-604	606	4	2	28	6
[illegible]-605	607	3	2	24	6

NOTES:

1. TRIM AS REQUIRED TO FIT VESSEL AND INTERNAL PIPING.

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
ANTI-VORTEX BAFFLES

EXXON RESEARCH AND ENGINEERING Co.

E.C. VATH / R.W.B.

DWG No. 1722-9-A

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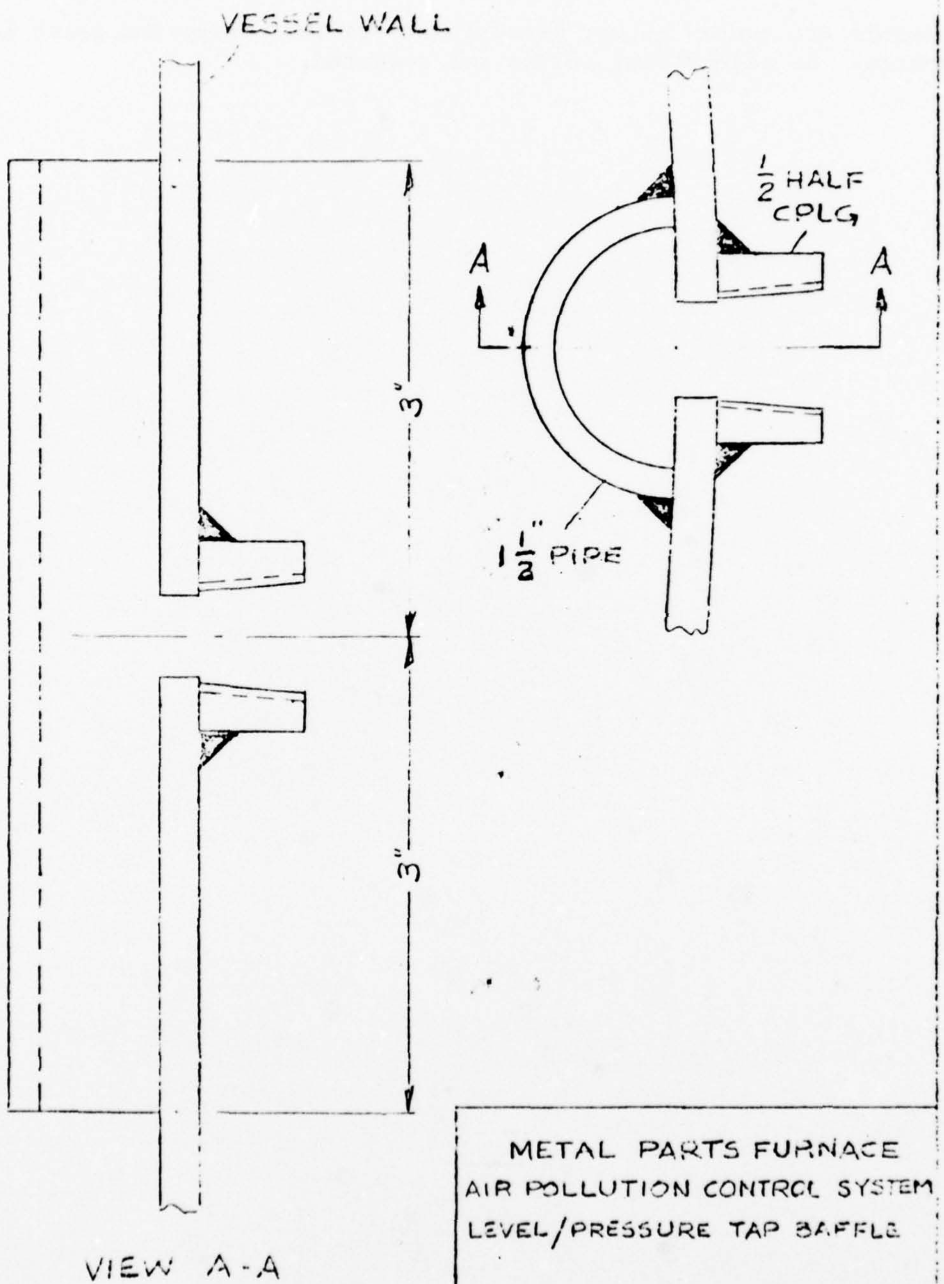

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
LEVEL/PRESSURE TAP BAFFLE

EXXON RESEARCH & ENGINEERING CO.

DWG. NO 1722-14-A

Safety Facilities

All vessels are vented either directly or via the blower and stack to atmosphere. No safety vent valves are required.

Miscellaneous

Stack

The stack shall be a field erectable, self supporting carbon steel pipe, 30 inches in diameter, constructed in two 25 ft. sections to provide a discharge port 50 feet above the ground. It shall be designed and supported to withstand 80 mph winds. The gas inlet port shall be sized to match the exhaust blower and shall enter the stack 45° from the horizontal.

The stack shall be provided with two sampling ports, 90° apart, on the same horizontal plane. These ports shall be located a minimum of 10 stack diameters downstream from the gas entry port and a mimimum of 10 stack diameters from the stack discharge (between approx. 30 ft. and 40 ft. above grade). Each port shall be fitted with a permanently attached 4 inch (minimum) diameter pipe 4 inches in length. Suitable scaffolding shall be designed by the contractor to permit access to the stack sampling ports.

Design Flow Plan

NOTES:

1. All fresh caustic and well water piping and valves to be carbon steel. All salt solution (slurry, brine, purge, product) piping and valves to be monel. Carbon steel can be considered for piping and valves, with reduced lifetimes.

2. The contractor shall provide appropriate 125 psig steam piping for the internal heating coils in the retention tanks and the salt dryer feed tank, and for the analyser system heated sampling line. Pressure reducing regulators shall be provided.

3. Piping to multiple nozzles, as required for the venturi slurry inlets and scrubbing tower clean liquor distributor and bypass inlets, shall provide for near equal fluid distribution to each nozzle.

4. All pressure gages shall be visible from grade or from otherwise available platforms or scaffolding.

5. All remotely operated valves shall be equipped with suitable position indicators for on-site visual inspection.

6. The contractor shall determine available control valve pressure drops based on final elevations and equivalent piping distances.

7. The contractor shall pipe 80 psig well water to 1/2" blowback taps immediately upstream from the suction block valves of each of the solids-handling pumps. (Not shown on design flow plan.)

E. Brine Processing

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the brine processing equipment as specified herein.

b. Subassemblies shall be erected by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. As part of the work, the Subcontractor shall provide the necessary technical direction for unloading and erection of the dryer subassemblies.

d. As part of the work, the Subcontractor shall provide the necessary technical direction of start-up service and training of operator personnel.

e. The equipment will be installed within a heated area which is housed within a protective enclosure. Ambient conditions within the shrouded area will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods.

f. Brine processing subassemblies shall be transportable by railroad flat car. Subassembly breakdown shall be approximately as shown on the Concept Design Drawing, sheet L-55. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

g. The salt dryer units shall be shop tested prior to shipment to the installation site. Testing will consist principally of mechanical operation checks.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Components

a. Salt Dryers

Three (3) twin rotary drum dryers, each having a minimum of 165 square foot of effective heat transfer surface. Drum dimensions to be a minimum of 32" diameter x 120" length.

1) Drums are steam heated steel with a chrome plated surface finish. Internal drum pressure rating to be 150 psig in accordance with ASME standards for pressure, mechanical stability and flange strength. Drums are to be vented to expel air with an internal syphon system to prevent accumulation of condensate.

2) Drums are to be reinforced as required to meet clearance between the drums.

3) Drum chrome plating to be a minimum of 0.006" thickness.

4) Main bearings to be self-aligning, split sleeve type, with automatic adjustment.

5) Centralized lubrication system to be included.

6) Knives to be tempered tool steel with pneumatic knife adjustment.

7) Knives and screw conveyors to be completely enclosed for dust control. Manufacturer to specify air exhaust ventilation requirements to maintain adequate dust control.

8) Feed arrangement to be splash type.

9) Stainless steel vapor hoods to be furnished complete with 8000 cfm, 0.25" w.c. pressure rise, axial flow exhaust fan and stack. Stack height to be 36'-0 above dryer concrete support base.

10) Drive to be variable speed.

11) Screw conveyors required to convey dry salt from discharge points to the vertical lift bucket elevator. Conveyors to consist of a stainless steel trough with cadmium plated steel screws.

12) Bucket elevators required for each individual unit to lift product salt to a discharge point 20'-0 above the floor. Bucket elevator to be stainless steel.

b. <u>Horizontal Screw Conveyors</u>

Three (3) screw conveyor units are to be provided for conveying the dried salt from the salt dryer unit bucket elevator discharge points located 20'-0 above the floor to the product salt bins.

1) Screw conveyors are to have stainless steel troughs with cadmium plated steel screws.

2) Each screw conveyor unit to have an integral motor, reducer and drive.

3) Troughs are to be enclosed.

4) The discharge chute from the third conveyor unit shall be bifurcated with two (2) covered chutes leading to flanged inlet connections on the dry salt bins. A diverter shall be included to permit operator selection of the chute to be used. Chutes, diverters etc. are to be stainless steel.

c. Salt Storage

Two (2) storage bins are to be provided for holding dried salt product. Each bin will be a 6'-0 diameter tank having a 10'-0 straight cylindrical side. Conical hoppers are to be attached to the cylindrical tanks. The hopper sides are to be sloped at 60^{o} from the horizontal. For structural design purposes, the weight of the dry salt shall be assumed to be 30 lbs/cu ft. Bottom outlets shall terminate in a 6" diameter, flanged outlet.

1) Storage bins and hoppers to be fabricated using stainless steel plates having a minimum of 10 gauge wall thickness.

2) Each bin shall have a conveniently located, flanged, gasketed access opening.

3) The discharge of each bin will be fitted with a manually operated outlet damper to permit operator filling of 55 gallon steel drums.

4) The discharge point of each bin will have a dust control cover, designed to surround the open top of a 55 gallon steel drum. The cover to be fabricated using light gauge steel, complete with a dust collection connecting flanged opening.

5) Each bin shall have structural support legs, flanged for removal during shipment. Legs are to be of sufficient length to permit 55 gallon drum to fit under fill-point dust cover when supported on a 6" high floor roller conveyor. Top of bin to be approximately 20'-0 above the floor.

6) Flanged opening for bin level sensing elements shall be provided.

d. Roller Conveyor

Roller conveyor units will be mounted under the salt bins and adjacent to the compactor to facilitate movement of both empty and filled 55 gallon steel salt drums.

1) Conveyor units will be of steel construction.

2) Rollers will be equipped with permanently lubricated anti-friction bearings.

e. Drum Compactor

A compactor unit will be furnished for compaction of the salt in the 55 gallon drums.

f. Bag Type Dust Collector

The equipment will include a dry type baghouse dust collector, dust collection ductwork, and an exhaust system, including an induced draft fan and gas exhaust stack to elevation plus 36'-0 above the floor, complete with hardware and accessories as specified herein.

1) One (1) baghouse collector to be of the dry bag type having a minimum air to cloth ratio of 8:1, including support steel, particulate hopper, and integral bag cleaning device with an automatic timer.

2) Complete set of dacron felt or equal bags.

3) One (1) ventilation system for the collector including fan, fan bearing lubrication, supporting base for mounting on bag collector, motor slide base, vibration isolation components and expansion joints as required by equipment design, fan and motor sheaves, V-belts, V-belt guard, electrical drive motor and motor starter.

4) One (1) set of outlet ductwork from the fan exhaust to elevation plus 36'-0 including hardware for field installation. Roof flashing not included.

5) One (1) set of interconnecting ductwork and expansion joint as required by the design to connect the baghouse outlet to the fan.

6) One (1) set of ductwork to connect the collection points on the salt dryers, fill points, and material handling transfer points to the inlet side of the collector. Manual dampers for system balancing are to be included.

7) Complete set of gaskets, bolts, nuts and washers required for field connections and erection of the equipment.

8) One (1) gravity double tipping airlock assembly for hopper discharge.

9) Ladder and work platform with guard rail to be furnished.

10) Collector flow rate will be 3000 cfm. Gas will be air at 180 F or less. Dust will be dried salt collected at a velocity of 300 fpm. Dust loading will be 0 to 5 grains per DSCF.

11) Collector will meet 99% by weight removal efficiency for particulate matter 1 micron and larger. Collector will operate continuously.

12) Compressed air is available at 80 psig.

13) The dust collector shall be shop assembled complete with the fan mounted and tipping valve in place. Ductwork, ladder, platform, etc. are to be shipped loose.

g. Brine Piping

Piping will be field installed to connect each salt dryer feed point to the salt brine feed pumps, P-309.

1) Pipe will be steel, schedule 40.

2) Manual gate valves are to be provided to permit isolation of dryer units.

h. Brine Sump

Floor drains in the brine evaporation and certification tank area will be provided for washdown to a common sump. Overflow brine from the dryers will flow by gravity to the sump. Pump P-312 pumps both streams from the common sump back to the salt dryer feed tank, D-604.

6. Rating

The total brine processing subsystem shall be designed to meet a production rating of 1031 lbs/hour (bone dry salt) based on a brine at 80.0% H_2O and a dry salt product containing less than 14% H_2O by weight. This subsystem will also have a design rating of 125% of the production rating or 1290 lbs per hour of bone dry salt.

Each individual unit is to be sized for 1/3 of the total system rating.

The approximate salt composition in weight %:

Na_2CO_3	30.0
NaCl	33.0
Na_2SO_4	37.0
NaOH	trace

7. Utilities

Steam will be furnished at a nominal rate of approximately 5900 lbs/hour and 7375 lbs/hour maximum or design rate. This steam will be furnished at 125 psig at the dryer inlets.

Compressed air at 60 psig will be provided for the knife adjustment cylinders.

F. Electrical Equipment

1. Motors

Electrical motors will be Westinghouse, "Mill and Chemical", or equal. The "Mill and Chemical" motor has a cast iron housing with a chromated red oxide primer, rich in zinc, over which is applied a full gloss epoxy enamel top coat for resistance to acid, alkali fumes, salt air, moisture and chemical spillage. These motors will be furnished with TE.FC. construction, for 460 volt, 3 phase, 60 Hertz power utilization. Service factor of 1.15, 40^{0} ambient class "F" insulation.

2. Motor List

1 - MPL transverse ball screw drive . . .	3/4 hp, 1200 rpm - DC
1 - MPL longitudinal ball screw drive . .	3/4 hp, 1200 rpm - DC
1 - MPL roller table drive	1 hp, 1800 rpm(R)
1 - CHARGE CAR carriage drive	3/4 hp, 1800 rpm(R)
1 - CHARGE CAR roller table drive	1 hp, 1800 rpm
1 - FURNACE main roller hearth drive . .	2 hp, 1800 rpm
1 - FURNACE hydraulic door and punch drive	15 hp, 1800 rpm
1 - DISCHARGE CAR carriage drive	3/4 hp, 1800 rpm(R)
1 - DISCHARGE CAR roller table drive . .	1 hp, 1800 rpm
1 - TRAY RETURN roller table drive . . .	1 hp, 1800 rpm
1 - UNLOAD TABLE roller table drive . . .	1 hp, 1800 rpm(R)
2 - AIR COOLING CHAMBER roller table drive	1 hp, 1800 rpm(R)
2 - AIR COOLING STATION door lift drive .	1/2 hp, 1200 rpm(R)
2 - BIF SHROUD isolation door operator .	1/2 hp, 1200 rpm(R)
2 - MPL shroud isolation door lift drive	1/2 hp, 1200 rpm(R)
1 - SCRAP electro-magnet	5 hp (equiv.)

METAL PARTS FURNACE
DAAA15-74-C-0092

1 -	REHEATER combustion air blower . . .	3 hp, 3600 rpm
1 -	CONTROL HOUSE ventilation fan	1/2 hp, 1800 rpm
1 -	SCRAP dump hoist drive	1 hp, 1800 rpm(R)
1 -	SCRAP bridge crane drive	3 hp, 1800 rpm
1 -	SCRAP hoist traction drive	1/2 hp, 1800 rpm
1 -	BURSTER roller table drive	1 hp, 1800 rpm(R)
1 -	SCRAP hoist traction drive	1/2 hp, 1800 rpm
1 -	SCRAP loading hoist drive	1 hp, 1800 rpm
2 -	FURNACE combustion air blower (p/b) .	10 hp, 3600 rpm
2 -	FURNACE combustion air fan	40 hp, 1800 rpm
1 -	FURNACE sparging air blower	3/4 hp, 1800 rpm
2 -	AIR COOLING CHAMBER recirculation fan	5 hp, 1200 rpm
*1 -	SCRUBBER induced draft fan	150 hp, 1800 rpm
2 -	BOILER combustion air fan (p/b) . . .	10 hp, 1800 rpm
2 -	BOILER fuel oil pump (p/b) (P-314) .	1 hp, 1800 rpm
2 -	FUEL OIL supply pump (p/b) (P-313) .	1/2 hp, 1800 rpm
1 -	BOILER condensate return pump (P-316) .	3/4 hp, 1800 rpm
2 -	BOILER feedwater pump (p/b) (P-315) .	15 hp, 1800 rpm
2 -	TREATED water pump (p/b) (P-317) . . .	1/2 hp, 1200 rpm
2 -	BRINE purge pump (p/b) (P-301) . . .	2 hp, 1800 rpm
2 -	QUENCH brine pump (p/b) (P-302) . . .	3 hp, 1800 rpm
2 -	QUENCH brine return pumps (p/b) (P-303)	3 hp, 1800 rpm
2 -	VENTURI slurry pump (p/b) (P-304) . .	10 hp, 1200 rpm
2 -	CLEAN liquor pump (p/b) (P-305) . . .	7.5 hp, 1800 rpm
3 -	BRINE product pump (P-306,307,308) .	2 hp, 1800 rpm

2 - BRINE dryer feed pump (p/b) (P-309) . 2 hp, 1800 rpm

2 - CAUSTIC supply pump (p/b) (P-310) . . 1 1/2 hp, 1800 rpm

1 - pH sample pump (P-311) . . . . 1/8 hp, 1200 rpm

1 - DRYER brine return pump (P-312) . . . 5 hp, 1800 rpm

2 - FLOOR WASH sump pump (p/b) (P-318) . 3/4 hp, 1200 rpm

3 - DRYER drum drive . . . . 15 hp, 1200 rpm

3 - DRYER splash feeder . . . . 5 hp, 1800 rpm

6 - DRYER screw conveyor . . . . 1/2 hp, 1200 rpm

3 - DRYER ventilation fan . . . . 1 hp, 1200 rpm

3 - DRYER overhead screw conveyor . . . . 1 hp, 1200 rpm

3 - DRYER bucket elevator/screw conveyor 1 hp, 1200 rpm

1 - DRYER knife dust exhaust fan . . . . 5 hp, 1800 rpm

1 - COMPACTOR drive . . . . 5 hp, 1200 rpm

1 - BRINE pipeline tracing . . . . 5 kw

1 - AIR CONDITIONER - instrumentation . . 2 hp, 1800 rpm

1 - SAMPLE LINE pipeline tracing . . . . 3 kw

1 - REVERSE Osmosis pump unit . . . . . . 15 hp, 1200 rpm

ESTIMATED TOTAL INSTALLED HORSEPOWER - 440
(not including redundant motors)

*Requires 2 speed motor for startup and emergency power operation. (p/b) indicates primary and backup.

3. Motor Control

Motor control will be Furnas, or equal, Motor Control Centers NEMA 1 non-walk-in enclosure, NEMA Type 1B wiring, based upon a 460 volt, 3 phase, 60 Hertz power supply with 120 volt single phase control.

a. Motor control centers will be furnished as follows:

1) MCC #1 - Four (4) sections, 80" high x 18" deep x 80" long.

2) MCC #2 - Eight (8) sections, 80" high x 18" deep x 160" long.

3) MCC #3 - Seven (7) sections, 80" high x 18" deep x 140" long.

b. Power distribution will be as shown on the one-line electrical diagrams, Concept Design Drawing, Sheets L-62 and L-63.

4. KVA Requirements

The total installed horsepower (not including redundant motors) amounts to 440. Using nominal load factors of 0.5, 0.75, and 1.0 where applicable, we estimate the power requirement at 440 kw at 490 kva.

5. Standby Power

Standby or emergency power is required to maintain the safety support functions when a main power failure occurs. The key elements, therefore, are the exhaust fans, the ventilation fans, shroud isolation doors recycle pumps and the quench pumps.

The scrubber induced draft fan will have an 1800/900 rpm motor for reduced speed on startup and during a power bronw-out. The nominal horsepower requirement is 20 hp at the reduced speed. The total list of standby power items will include:

Furnace combustion air blower . .	10 hp
Control power	1 hp (equivalent)
Scrubber fan	20 hp
Shroud isolation doors	2 hp
Fuel oil pumps	1/2 hp
Boiler fan and pumps	25 hp
Furnace hydraulic pump	15 hp
Furnace drive	2 hp
Treated water pump	1/2 hp
Brine tracing	5 kw
Clean liquor pump (P-305)	7.5
Slurry pump (P-304)	10
Quench brine return pump (P-303) .	3

Purge pump (P-301)	2
Furnace combustion air fan	40 hp

ESTIMATED STANDBY HORSEPOWER - 140 hp

Design factors and requirements for the emergency power, standby generator are specified as follows:

a. The 140 hp will be a peak short term demand, having a term of from 10-15 minutes.

b. Sustained shut down need will require from 100 to 120 hp for a period of up to 2 hours.

c. The maximum "maintained contact" load will be 100 horsepower.

d. Converting to power, the requirement will be 155 kva for the loads defined above. Correspondingly, we estimate a demand for approximately 140 kw. We will recommend a 150 kw standby power set. For selection of a standard diesel electric generating set, we must correct for elevation (5000 ft) using a divisor of 0.84. Therefore, the rated generator power requirement will be 140 ÷ 0.84 = 166 kw. The required kva will be 131 ÷ 0.84 = 185 kva for nominal nameplate rating of the diesel electric generator set.

e. The standby electric plant shall be a Kohler Model 150R071, or equal, rated at 150 kw, 187.5 kva, 460 volt, 3 phase, three wire, 0.8 power factor, 226 amps, 60 Hertz AC generator. The engine shall be a 6 cylinder diesel rated at 248 hp at governed speed of 1800 rpm. Starting shall be 24 volt automotive cranking. Engine will be liquid cooled with a radiator and blower type fan.

f. Generator will conform to NEMA standards. It will be direct connected to the engine crankshaft.

g. A line transfer switch shall be provided to automatically start the generator and transfer the load in the event of normal source voltage falling to 70% of the nominal.

h. Approximate size of electric plant:

Length	Width	Height	Net Weight
105"	36"	65"	5150 lbs

i. Fuel supply will be by gravity flow line from the main fuel supply tank.

j. The unit will be manually started and serviced on a daily basis.

k. The unit will be shop tested prior to shipment to demonstrate rated power output, operating efficiencies, etc.

6. Illumination

The concept design data and specifications for the illumination system are shown on the Concept Design Drawings, Sheets L-60 and L-61.

7. Grounding

The concept design data and specifications for the plant grounding and lightening protection system are shown on the Concept Design Drawing, Shee L-64.

8. Standard Specification for Wires and Cables

a. General

1) The purpose of this specification is to state the minimum requirements for wires and cables that shall be used for general mill buildings and appurtenances thereto that provide lighting, ventilation and other "utility" loads and for plant power feeders, transmission lines, service ties, plant control and other "production" loads.

2) All installations that require special wires and cables such as communication or telephone systems, TV monitor systems, computer systems, etc., shall be wired in accordance with manufacturer's requirements.

3) All installations in location where the copper temperature will exceed 75 C, where corrosive alkaline, acid, or oil conditions exist, and other such installations shall be wired in accordance with latest IPCEA requirements.

4) Each coil or reel of wire and cable furnished shall bear a tag containing the Underwriters' Laboratories approval stamp (providing cable is of the class inspected by said Laboratory), name of manufacturer, trade

designation, and month and year of manufacture; and in no case shall be more than six (6) months old.

b. 600 Volt Cable

1) 480 Volt "power" circuits installed in conduit shall conform to the following:

a) Single conductor, concentric Class B construction, stranded, soft drawn annealed, coated copper conductors with cross-linked polyethylene insulation, 90 C, Vulkene Table SI-58063 or approved equal.

b) 110/220 Volt "lighting" circuits installed in conduit shall conform to a) above or under approved locations to the following:

Underwriter's Type "TW", single conductor, with concentric Class B construction, stranded, 660 volt, soft drawn annealed, coated copper conductors, and meet all IPCEA Appendix 1, latest edition insulation requirements. Sizes limited to #12 through 1/0. Conductors to have minimum 3/64 inch wall insulation.

c) Control Cable shall conform to the following:

Multiconductor, 600 volt concentric copper conductors, each conductor to be No. 12 or 14 as specified, 7 strand tinned wire, insulated with cross-linked polyethylene, 90 C, Vulkene or approved equal, color coded per Method 3, Section 6.5.5.2, IPCEA Spec. #S-19-81, latest addition. Number of conductors to be limited to 19 unless otherwise specified. Fillers to be used where necessary for proper cabling on assembly. Outer jacket shall be black neoprene meeting IPCEA Standard S-19-81, Section 4.13.3, and shall indicate manufacturer, type of cable, number of conductors, and voltage rating. Cable shall be Vulkene Table SI-58145 or approved equal.

d) Ammeter Shunt Leads shall consist of two conductor layformed cable as defined in Paragraph c).

e) 600 Volt DC mill drive motor circuits installed in conduit shall be as defined in Paragraph a).

f) 250 Volt DC power circuits installed in conduit shall be as defined in Paragraph a).

g) Three phase power circuits in cable tray shall be suitably triplexed or bound together with tiewraps on 18" centers.

9. Standard Specification for Individual Low Voltage A.C. Motor Starters and A.C. Motors

a. Individual Low Voltage A.C. Motor Starters

1) The minimum size starter for 220 volt, 440 volt, three phase motors shall be size 1.

2) Sizes 1, 2, 3 and 4 starters are to be of the fused switch combination type.

3) Sizes 5, 6 and 7 are to be combination type with safety view circuit breaker.

4) All starters are to be provided with NEMA 1 unless surrounding atmospheric conditions justify explosion-proof or NEMA 3R rain-tight enclosures.

5) If hazardous atmospheric conditions exist, NEMA 7 enclosures shall be provided.

6) If starters are to be located remote from motor control centers, a NEMA 3R enclosure shall be provided.

7) When pushbutton stations are required, they shall be provided with the same NEMA type enclosure as the starter with which they are used, shall be separately mounted at a minimum distance of 6'-0", and shall be of the heavy duty type. In lieu of 3R, NEMA 12 may be used.

8) All starters are to be provided with visible type disconnect device and Busman Fusetron fuses with current limit features only.

9) All starters are to be provided with control transformers mounted in starter enclosure. The control transformers are to be provided with 440 volt primary and 110 volt ungrounded secondary, and proper secondary fusing.

10) All starters to have overload protection in two phases. All overloads are to be selected to carry 125% of full load motor current. The overload element shall be designed for hand reset after thermal trip.

11) Starter sizes, disconnect device, fuse mounting type, and fuse size are to be selected for the following table:

Full Load Mot Amps	Starter Size	Disconnect Device	Fuse Clips
1.4 to 5	1	Visible	600 volts 30 amps
5 to 15	2	Visible	600 volts 60 amps
16 to 25	3	Visible	600 volts 100 amps
26 to 40	3	Visible	600 volts 200 amps
41 to 80	4	Visible	600 volts 400 amps
81 to 125	5	Visible	600 volts 400 amps
126 to 200	5	Visible	600 volts 600 amps

b. A.C. Motors

1) A.C. motors shall be of the totally enclosed, mill and chemical, fan-cooled type; except enclosed non-ventilated, or other as indicated by application and approved by the Contracting Officer.

2) A.C. motors shall be of the standard NEMA frame sizes and equipped with antifriction bearings.

3) A.C. motors on special application less than 1/2 hp shall be 110/220 volts, single phase, 60 cycle.

4) A.C. motors 1/2 hp through 400 hp shall be 440 volts, 3 phase, 60 cycle, squirrel cage induction, Class F insulation as application may require, and continuous rated.

5) All gear motors are to be of the all-motor type.

G. Process Controls

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver process control equipment as specified herein.

b. The process control equipment shall be installed by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The instrumentation will be installed within protective enclosures. Ambient conditions within the enclosed areas will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Description

a. Temperature Control in MPF during Volatilization Mode

The key to minimizing processing time in the controlled volatilization process, lies in rapidly preheating the work at high input, followed by precise temperature control during volatilization at low input. The conversion from the preheating mode to the volatilization mode is critical. If the conversion is made too soon, the furnace capacity will be reduced. If it is made too late, the PFB will be overloaded causing an excessive PFB temperature. This conversion will be accomplished with a differential head type control. The furnace control will be accomplished with the following elements:

Controller		Valve	Sensor Location	Set Point
T-205-RC	Impingement Burners	R-205,R-206	PFB	1600
T-204-RC	Heat-up Burners	R-204	Vol Chamber	1000
T-202-C	PFB Burners	R-202	PFB	1500
T-201-RC	AFB Burners	R-201	AFB	1650
T-203-RC	PFB Air	R-203	PFB	1550
T-407-C	Vol Chamber Steam	R-407	PFB	1625
	Vol Chamber Fog	F-503,504	PFB	1675
	Vol Chamber Purge	P-408	Timer	

At the start of a cycle, the PFB and AFB burners will be firing to maintain 1500 F in the PFB and 1650 F in the AFB, the PFB air for Mustard burning will be shut off, and all the burners in the volatilization chamber will be firing. The input to the PFB burners will remain constant for this processing mode. When the cycle is about 25% complete, initial volatilization will be noted by an increase in the PFB temperature. At this time the heat up burners in the volatilization chamber will shut off and the work will be heated by the impingement burners only. When the PFB temperature reaches 1550 F the PFB Mustard air supply will start opening (T-203-RC). This air supply will be set to deliver the rated capacity when the control valve (R-203-CV) is fully open. As the PFB temperature increases to 1600 F, the PFB temperature control will shift to the impingement burners (T-205-RC), thus completing the conversion from the preheating to the volatilization mode. The actual set points of T-204 and T-205 will be controlled by the differential heat computer.

For the remainder of the cycle time, the temperature in the PFB will be controlled by adjusting the volatilization rate via input to the impingement burners. This will be a cascade control to compensate for the system lag. At the end of the cycle, the impingement burners will be fully open (R-205,6), but the PFB temperature will decrease due to insufficient Mustard. When the PFB temperature drops to 1550 F, the PFB will start cutting back. When R-203 reaches its minimum position, the cycle will be complete.

There are two steam supplies to the MPF. Controller T-407-C introduces cooling steam to the volatilization chamber in case of a temperature excursion in the PFB. The steam rate will be about 4560 lbs/hr, but it is expected that will be used a maximum of 10 minutes per cycle. Purging steam will be supplied through P-408-CV during the volatilization period. This valve will be controlled by a timer to shut off the flow during the preheat period. A continuous steam flow will be taken from upstream of P-408-CV to pass through the fog nozzles to assure they are not blocked. If the temperature excursion is not corrected by steam cooling (T-407-C), the furnace will be shut down quickly by spraying into the volatilization chamber through the fog nozzles (F-503,504).

The burn-out chamber will operate independently from the volatilization chamber. The burners will fire on ratio and will be controlled by T-207-RC. The extra air necessary for sludge combustion will be supplied through F-223-BV. This valve will be controlled by timer to close at the end of the cycle. When the work is transferred from the volatilization chamber to the burn-out chamber, there will be no excess air in the burn-out chamber. If there is residual Mustard in the work, the opening of F-223-BV will be delayed until volatilization is complete, otherwise it will open at the start of the cycle. Excess combustion air will be supplied to the AFB to assure any agent volatilized in the burn-out chamber can be burned completely.

b. Temperature Control in MPF during Non-volatilization Mode

When drained projectiles are processed, the differential head controller will be inoperative. Temperature control in the volatilization will be with T-204-RC and in the PFB with T-202-C. The burn-out chamber and AFB will remain on their independent control. Therefore, the differential head controllers must be equipped with overrides.

c. Air Pollution Control Instrumentation

The air pollution control system is designed and instrumented to avoid process interruptions during volatilization. Generally, pollution control system upsets sound alarms which alert the operator of trouble. The MPF will only be shut down in the case where the upset is critical and cannot be corrected.

The bulk of the instrumentation in the Pollution Control System is used to control the liquid flows and concentrations. Most of the liquid flows will be controlled by flow control valves setting a constant pressure drop across a metering orifice. The two exceptions are the fresh caustic addition and fresh water addition. Fresh caustic will be added in response to the pH controller. The fresh water must be added at a rate equal to the evaporation rate in the quench to keep a constant salts concentration. The evaporation rate will be reasonably constant when processing drained items. When Mustard is being processed, the evaporation rate will change drastically during the cycles. Therefore, fresh water addition will be controlled from two signals. The base line flow will respond to salts concentration in the scrubber sump. Changes in evaporation rate will be compensated by increasing the fresh water addition in response to increases in the PFB air (R-203). There will be no signal from R-203 with drained items.

d. Draft Control in MPF

The four major elements in the furnace draft control are the induced draft fan damper (P-501-CV) and the dampers in each of the lines leading from the furnace chambers to the afterburners (P-502,503,504). The total gas flow will be controlled by P-501-RC. The draft in the furnace chamber will be controlled by P-502-RC, P-503-RC and P-504-RC. The dampers for the punching chamber and burn-out chamber will be interlocked to close when the outer doors are opened. The furnace pressure will be controlled slightly below the pressure in the shroud surrounding the furnace. The volatilization chamber pressure will be lower than the other two chambers so that door leakage will be into the volatilization chamber. During normal operations, the dampers will open or close in response to changes in furnace pressure caused by changes in burner input, etc.

e. Flame Supervision on Afterburners

Flame supervision is only required when the afterburners are below 1400 F (during heat up). If the burner flame extinguished when the temperature was above 1400 F, the fuel would still ignite from the hot refractory. Therefore, in order to avoid nuisance shut down due to false signals from the flame sensors, the flame safety system will be come inoperative when the afterburner temperatures are above 1400 F. The oil and air pressure switches will still be operative at this time. There will also be a holding system to maintain the integrity of the safety circuit between the time the power fails and the emergency power comes on line.

f. General Information

The thermocouples will be heavy gauge Type K in the high temperature regions, and Type J in the low temperature regions. The couples will be enclosed inside inert protection tubes to exclude leakage and contamination. Each of the critical sensing points will have redundant thermocouples to reduce nuisance shutdowns.

Liquid monitors will be purged to avoid blockage of sample holes.

Controller T-207 will actuate a timer to verify the length of time the burn-out chamber is above certification temperature.

The following variables should be monitored by the CAMDS system process control computer:

1. PFB temperature - T-203-RC
2. AFB temperature - T-201-RC
3. Volatilization chamber temperature - T-204-RC
4. Burn-out chamber temperature - T-207-RC
5. Quench temperature - T-021-C
6. Scrubber pump around pH - pH-001-RC
7. Volatilization chamber draft - P-503-RC

8. Venturi pressure drop - P-001-dRC

9. Burn-out chamber draft - P-504-RC

10. Quench sump level - L-001-RC

METAL PARTS FURNACE
DAAA15-74-C-0092

Temperature Control Equipment (1)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
METAL PARTS FURNACE							
T-204-RC	Volatilization Chamber Temperature	Volatilization Chamber Main Burners via R-204-CV	TC in Volatilization Chamber	Prop	400-1200 F	Yes	High Limit
T-205-RC	Volatilization Chamber Temperature	Volatilization Chamber Impingement Burners via R-205-CV and R-206-CV	TC in PFB	"	1450-2200 F	Yes	
T-407-C	Volatilization Chamber Over Temperature	Cooling Steam via R-407-BV	TC in PFB	On-Off	1450-2000 F	No	
T-501-C	Furnace Shut Down	Fog Nozzle Cooling Water Flow via F-501-BV, F-502-BV, S-503-BV, F-504-BV	TC in PFB	On-Off	1450-2200 F	No	
T-224-C	Differential Heat	Set Points of T-204, T-205					
T-207-RC	Burn-out Chamber Temperature	Burn-out Chamber Burners via R-207-CV	TC in Burn-out Chamber	Prop	600-1500 F	Yes	Certification Timer

METAL PARTS FURNACE
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Temperature Control Equipment (2)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
FUME BURNERS							
T-203-RC	PFB Temperature	Mustard Combustion Air via R-203-CV	TC in PFB	Prop	1450-2200 F	Yes	High-Low Valve Position
T-202-C	PFB Temperature	PFB Burner Air via R-202-CV	TC in PFB	"	1450-2200 F	No	High, Low Temperature Limit
T-201-RC	AFB Temperature	AFB Burner Air via R-201-CV	TC in AFB	"	1450-2200 F	Yes	High, Low Temperature Limit
AIR POLLUTION CONTROL SYSTEM							
T-021-C	Quench Tower Outlet	Diluge Water via R-021-BV	TC in Quench Outlet	On-Off	100-250 F	No	High Alarm
T-208-C	Stack Reheater Temperature	Stack Reheater Burner Air via R-208-CV	TC in Stack	High-Low	100-500 F	No	High, Low Temperature
P-411-BV	Control House Temperature	Steam Flow		On-Off	75 F	No	
P-412-BV	Booth Temperature	Steam Flow		On-Off	75 F	No	
P-413-BV	EGMS Temperature	Steam Flow		On-Off	75 F	No	

ber	Control Function	Controlled Variable	Sensor	Action	Range		
METAL PARTS FURNACE							
P-114-CV	Fuel Oil Supply Pressure	Recycle of Fuel Oil to Main Tank	Fuel Line Pressure	Prop	80-100 psig	No	Self Containe Regulator
P-501-RC	Furnace Draft Control	Damper on Induced Draft Fan P-501-CV	Press. Tap Gas Duct	"	0 to 40"w.c.	Yes	Low Limit
P-502-RC	Punching Chamber Draft	Damper Position in Punching Chamber Exhaust P-502-CV	Press. Tap in Punching Chamber	"	0 to 1"w.c.	Yes	Low Limit
P-503-RC	Volatilization Chamber Draft	Damper Position in Volatilization Chamber Exhaust Duct P-503-CV	Press. Tap in in Vol. Chamber	"	0 to 1"w.c.	Yes	Low Limit
P-504-RC	Burn-out Chamber Draft	Damper Position in Burn-out Chamber Exhaust Duct P-504-CV	Press. Tap in Burn-out Chamber	"	0 to 1"w.c.	Yes	Low Limit
P-405-CV	Volatilization Chamber Steam	Purge Steam Pressure		"	125 psig	No	Self Contained Regulator
P-406-CV	Volatilization Chamber Steam	Cooling Steam Pressure		"	125 psig	No	Self Contained Regulator

METAL PARTS FURNACE
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Pressure Control Equipment (2)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
AIR POLLUTION CONTROL SYSTEM							
P-001-dRC	Venturi Pressure Differential	Venturi Throat	Pressure Transducer	Prop	10-20"w.c.	Yes	Low, High Alarm
P-002-dI	Scrubber Pressure Differential					No	High Alarm
P-003-dI	Demister Pressure Differential					No	High Alarm
P-011-CV	Scrubber Pump 301 Bypass	Scrubber Sump Mixing Flow		Prop		No	Self Contained Regulator
P-012-CV	Scrubber Pump 305 Bypass	Scrubber Pump Around Mixing Flow		"		No	Self Contained Regulator
P-013-CV	Quench Pump 303 Bypass	Quench Sump Mixing Flow		"		No	Self Contained Regulator

METAL PARTS FURNACE
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Pressure Control Equipment (3)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
P-014-CV P-015-CV P-016-CV	Retention Tank Pump Bypass	Retention Tank Mixing Flow				No	Self Contained Regulator
P-017-CV	Salt Dryer Feed Tank Pump 309 Bypass	Salt Dryer Feed Tank Mixing Flow				No	Self Contained Regulator
P-018-CV	pH Sample Pump 311 Bypass	pH Sample Flow				No	Self Contained Regulator
P-019-CV	Analyzer Sample Bypass	Analyzer Sample Flow				No	Self Contained Regulator
BRINE TREATMENT							
P-402-CV P-403-CV P-404-CV	Salt Dryer Steam	Heating Steam Pressure		Prop.	125 psig	No	Self Contained Regulator

Pressure Control Equipment (4)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
MISCELLANEOUS							
P-401-CV	Low Pressure Steam	Heating Steam Pressure		Prop	15 psig	No	Self Contained Regulator
P-508-CV	RO Water Outlet	Clean Water Pressure		"	30 psig	No	Self Contained Regulator

Flow Control Equipment (1)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
METAL PARTS FURNACE							
P-105-CV P-103-CV	Volatilization Chamber Burner Air/Fuel	Volatilization Chamber Main Burner Oil Flow	Pressure in B04 Combustion Air Line	Prop	25-400 psig	No	Balanced Pressure Regulator
P-104-CV	Volatilization Chamber Impingement Burner Air/Fuel	Volatilization Chamber Impingement Burner Oil Flow	Pressure in B03 Combustion Air Line	"	25-400 psig	No	Balanced Pressure Regulator
P-106-CV	Burn-out Chamber Burner Air/Fuel	Burn-out Chamber Burner Oil Flow	Pressure in B05 Combustion Air Line	"	25-400 psig	No	Balanced Pressure Regulator
F-110-MBV F-111-MBV	Volatilization Chamber Impingement Burner Safety Valve	Volatilization Chamber Impingement Burner Oil Flow	Safety Circuit	On-Off		No	Manual Reset
F-121-MBV	Volatilization Chamber Main Burner Safety Valve	Volatilization Chamber Main Burner Oil Flow	Safety Circuit	"		No	Manual Reset
F-112-MBV	Burn-out Chamber Burner Safety Valve	Burn-out Chamber Burner Oil Flow	Safety Circuit	"		No	Manual Reset
F-209-MBV	Volatilization Chamber Main Burner Safety Valve	Volatilization Chamber Main Burner Air Flow	Safety Circuit	"		No	Manual Reset

METAL PARTS FURNACE
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Flow Control Equipment (2)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
F-210-MBV F-211-MBV	Volatilization Chamber Impingement Burner Safety Valve	Volatilization Chamber Impingement Burner Air Flow	Safety Circuit	On-Off		No	Manual Reset
P-408-CV	Volatilization Chamber Steam	Volatilization Chamber Purge Steam Flow	Timer	"		No	Supplies Steam to Fog Nozzles
F-501-BV F-502-BV	Volatilization Chamber Shut Down	Fog Nozzle Water Flow					
F-503-BV F-504-BV	Burn-out Chamber Shut Down	Fog Nozzle Water Flow	Safety Circuit	"		No	
F-223-BV	Excess Air to Burn-out Chamber		Timer	On-Off		No	
FUME BURNERS							
P-101-CV	PFB Burner Air/Fuel	PFB Burner Oil Flow	Pressure in B01 Combustion Air Line	Prop	25-400 psig	No	
P-102-CV	AFB Burner Air/Fuel	AFB Burner Oil Flow	Pressure in B02 Combustion Air Line				

METAL PARTS FURNACE
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Flow Control Equipment (3)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
F-108-MRV	PFB Burner Safety Valve	PFB Burner Oil Flow	Safety Circuit	On-Off		No	Manual Reset
F-109-MRV	AFB Burner Safety Valve	AFB Burner Oil Flow	Safety Circuit	"		No	Manual Reset
AIR POLLUTION CONTROL SYSTEM							
F-001-RC	Brine Recycle to Venturi Flow	Orifice Pressure Drop	Pressure Transducers	Prop		Yes	Low Alarm
F-002-RC	Scrubber Pump Around Flow	Orifice Pressure Drop	Pressure Transducers	"		Yes	Low Alarm
F-003-RC	Quench Brine Flow	Orifice Pressure Drop	Pressure Transducers	"		Yes	Low Alarm
F-004-RC	Quench Water Flow	Orifice Pressure Drop	Pressure Transducers	"		Yes	
F-005-I	Retention Tank Caustic Flow		Pressure Transducers			No	Indicator Only
P-107-CV	Stack Reheater Air/Fuel	Stack Reheater Oil Flow	Pressure in B06 Combustion Air Line	"	25-400 psig	No	Balanced Pressure Regulator

METAL PARTS FURNACE
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Flow Control Equipment (4)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
F-113-MBV	Stack Reheat Safety Valve	Stack Reheat Oil Flow	Safety Circuit	On-Off		No	Manual Reset
F-415-BV	Make-up Water Flow	Receiver Tank Level		"		No	Signal from L-414-C

AD-A062 679 MIDLAND-ROSS CORP TOLEDO OH SURFACE DIV F/G 15/2
CONCEPT DESIGN REPORT. METAL PARTS FURNACE.(U)
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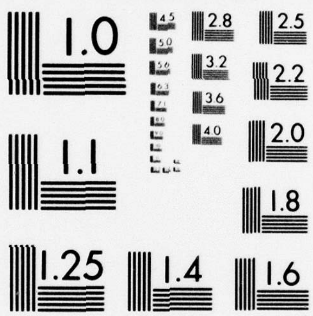
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Level Control Equipment (1)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
METAL PARTS FURNACE							
L-013 L-014	Floor Wash Sump Level	Wash from Sump to ADS		On-Off		No	
L-118-I	Emergency Fuel Oil Tank Level					No	Low, High Alarm Indicator Only
L-119-I	Main Fuel Oil Tank Level					No	Low, High Alarm Indicator Only
L-512-A	Head Tank Water Level					No	Low Alarm Only
L-001-RC	Quench Tower Sump Level	Brine Flow from Quench to Scrubber	Level Sensor	Prop		Yes	High & Low Alarm - High High & Low Low Contacts
L-004-RC	Scrubber Tower Sump Level	Brine Flow to Retention Tanks	Level Sensor	"		Yes	High & Low Alarm - High High & Low Low Contacts

Level Control Equipment (2)

Number	Control Function	Controlled Variable	Sensor	Action	Control Range	Recorder	Special Features
L-007-I	Caustic Storage Tank Level	Caustic Addition to Tank				No	High, Low Alarm No Control
L-008-I L-009-I L-010-I	Brine Retention Tank Level	Brine from Scrubber				No	High, Low Alarm No Control
L-011-I	Salt Dryer Feed Tank Level	Brine from Retention Tanks and Sumps		On-Off		No	High, Low Alarm No Control
BRINE TREATMENT							
L-012	Salt Dryer Brine Return Sump Level	Brine from Sump to Feed Tank		"		No	
L-414-C	Boiler Receiver Tank	Fresh Water Inlet		"		No	High, Low Alarm

PRESSURE SWITCHES AND ALARMS (1)

Number	Location	Action	Service	Range
MECHANICAL HANDLING EQUIPMENT				
	Low Pressure Hydraulics	LA	Hydraulic Fluid	500 psig
	High Pressure Hydraulics	LA	Hydraulic Fluid	1000 psig
	BIF Airlock Draft	LA	Air	0.2"w.c.
METAL PARTS FURNACE				
P-115-S,P-116-S	Fuel Oil Pumps	HA,LA	Fuel Oil	400 psig
P-122-S	Impingement Burners B03A,B	HA,LA	Fuel Oil	400 psig
P-123-S	Impingement Burners B03C,D	HA,LA	Fuel Oil	400 psig
P-124-S	Heat-up Burners B04	HA,LA	Fuel Oil	400 psig
P-125-S	Burn-out Burners B05	HA,LA	Fuel Oil	400 psig
P-214-S	Heat-up Burners B04	LA	Air	1.5 psig
P-215-S	Impingement Burners B03A,B	LA	Air	1.5 psig
P-216-S	Impingement Burners B03C,D	LA	Air	1.5 psig
P-217-S	Burn-out Burners B05	LA	Air	1.5 psig
P-221-S	Combustion Air	LA	Air	1.5 psig
P-409-S	Volatilization Chamber	LA	Cooling Steam	125 psig
P-410-S	Volatilization Chamber	LA	Purge Steam	125 psig
P-510-S	Fog Water	LA	Water	50 psig
P-219-S	Sparge Air	LA,HA	Air	60 psig
AFTERBURNERS				
P-126-S	PFB Burner Oil	LA,HA	Oil	400 psig
P-127-S	AFB Burner Oil	LA,HA	Oil	400 psig
P-214-S,P-220-S	PFB Combustion Air	LA	Air	.5 psig
P-213-S	PFB Burner Air	LA	Air	1.5 psig
P-227-S	AFB Burner Air	LA	Air	1.5 psig

FORM GEN - 81

PRESSURE SWITCHES AND ALARMS (2)

Number	Location	Action	Service	Range
AIR POLLUTION CONTROL SYSTEM				
P-004-LA	Caustic Pump 310	LA	Caustic	20 psig
P-005-LA	Slurry Pump 304	LA	Brine	20 psig
P-006-LA	Purge Pump 301	LA	Brine	20 psig
P-007-LA	Clean Liquor Pump P-305	LA	Caustic	20 psig
P-008-LA	Quench Brine Pump P-302	LA	Brine	20 psig
P-009-LA	Quench Brine Pump P-303	LA	Brine	20 psig
P-010-LA	pH Sample Pump P-311	LA	Brine	20 psig
P-128-S	Stack Reheater Oil	LA,HA	Oil	100 psig
P-218-S	Stack Reheater Air	LA	Air	1.5 psig
--	Boiler Controls			
MISCELLANEOUS				
P-505-S	Main Water Supply	LA	Water	30 psig
P-509-S	RO *High Pressure Water*	LA	Water	600 psig
P-511-S	RO Low Pressure Water	LA	Water	20 psig

FORM GEN - 51

MANUAL CONTROLLED REMOTE OPERATED VALVES

Number	Service	Fail Position
METAL PARTS FURNACE		
R-212-BV	Sparge Air to Burn-out (Timer)	FC
AIR POLLUTION CONTROL SYSTEM		
R-001-CV	Rinse Water to Demister Spray Bar	FC
R-002-CV	Clean Liquor Bypass	FC
R-003-CV	Quench Water Bypass	FO
R-004-CV	Quench Brine Bypass	FO
R-005-CV	Product from D-601 to D-604	FC
R-006-CV	Product from D-602 to D-604	FC
R-007-CV	Product from D-603 to D-604	FC
R-008-CV	Product from D-601 to Salt Dryer	FC
R-009-CV	Product from D-602 to Salt Dryer	FC
R-010-CV	Product from D-603 to Salt Dryer	FC
R-011-CV	Product from D-604 to Salt Dryer	FC
R-012-CV	Caustic Addition to D-601	FC
R-013-CV	Caustic Addition to D-602	FC
R-014-CV	Caustic Addition to D-603	FC
R-015-CV	Caustic Addition to D-604	FC
R-016-BV	Product from Scrubbing Tower to D-601	FC
R-017-BV	Product from Scrubbing Tower to D-602	FC
R-018-BV	Product from Scrubbing Tower to D-603	FC
R-019-BV	Product from Scrubbing Tower to D-604	FC
R-020-BV	Caustic Supply	FC
R-021-BV	Emergency Tower Water to Quench Tower	FO

MISCELLANEOUS

Number	Service	Fail Position
pH-001-RC	Scrubbing Tower pH	
D-001-I	Scrubbing Tower Sump Liquid Density	

FLOW SWITCHES

Number	Service	Action
METAL PARTS FURNACE		
F-506-S	Hydraulic Cooling Water	
F-507-S	Furnace Cooling Water	

LIMIT SWITCHES (1)

Number	Service	Action
MATERIAL HANDLING EQUIPMENT		
LS-01	BIF Air Lock Outer Door Down	
LS-02	BIF Air Lock Inner Door Down	
LS-03	Charge Car in BIF Position	
LS-04	Charge Car in Furnace Position	
LS-05	Charge Car in Burster Loader Position	
LS-06A,B	Tray Position on Charge Car (2)	
LS-07	Tray Position in BIF Air Lock	
LS-08	Tray Position in Burster Loader	
LS-09	Tray Position on MPL	
LS-10A,B	Tray Position on Discharge Car (2)	
LS-11	Tray Position in Cooling Station 1	
LS-12	Tray Position in Cooling Station 2	
LS-13A,B,C,D	Return Conveyor Tray Positions (4)	
LS-16	Scrap Hold Table Tray Position	
LS-17	Unload Table 1 Tray Position	
LS-18	Unload Table 2 Tray Position	
LS-19	Discharge Car in Furnace Position	
LS-20	Discharge Car in Cooling Station Position 1	
LS-21	Discharge Car in Cooling Station Position 2	
LS-22	Discharge Car in Unload Table Position 1	
LS-23	Discharge Car in Unload Table Position 2	
LS-24	MPL Door Down	
LS-25	MPL Door Up	
LS-26	Burster Loader Door Down	
LS-27	Burster Loader Door Up	
LS-28A,B	Cooling Chamber Door Up	
LS-29A,B	Cooling Chamber Door Down	

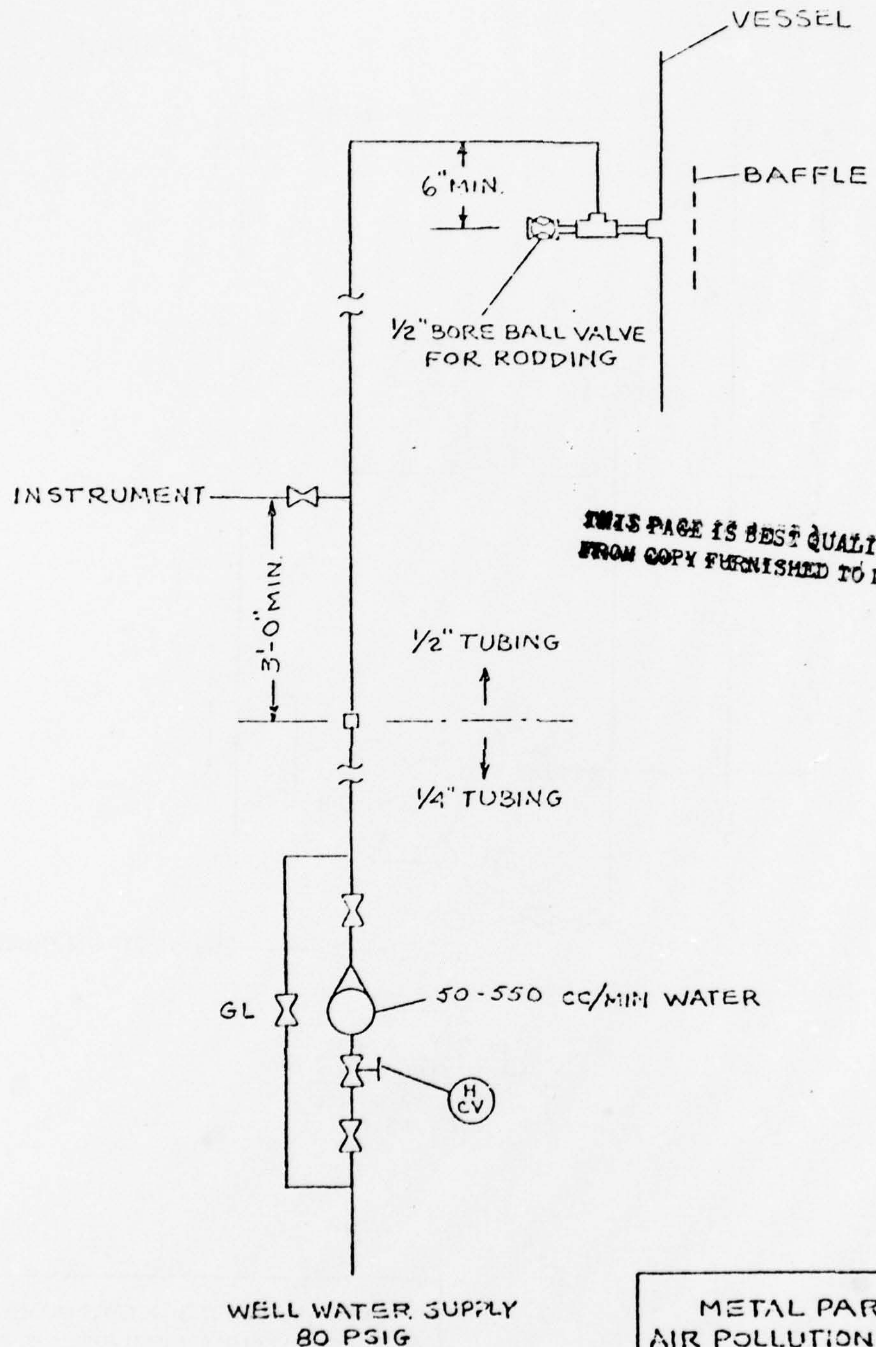
LIMIT SWITCHES (2)

Number	Service	Action
METAL PARTS FURNACE		
LS-51	Punching Chamber Outer Door Down	
LS-52	Punching Chamber Outer Door Up	
LS-53	Tray Position in Punching Chamber	
LS-54A,B	Punching Anvil Up (2)	
LS-55A,B	Punching Anvil Down (2)	
LS-56A,B	Punch Collar Down (2)	
LS-57A,B	Punch Through (2)	
LS-58A,B	Punch Up (2)	
LS-59A,B	Punch Collar Up (2)	
LS-60	Punching Chamber Inner Door Down	
LS-61	Punching Chamber Inner Door Up	
LS-62	Volatilization Chamber Tray Position	
LS-63	Volatilization Chamber Door Down	
LS-64	Volatilization Chamber Door Up	
LS-65	Burn-out Chamber Tray Position	
LS-66	Burn-out Chamber Outer Door Up	
LS-67	Burn-out Chamber Outer Door Down	

Instruments and Control Valves

NOTES

1. Orifice plates for F-001-RC and F-002-RC to be stellite or other suitable erosion resistant material.
2. R-002-CV, R-004-CV through R-011-CV, and control valves for solids bearing streams to be ball valves with stellite balls and proportional rotary actuators.
3. R-016-BV through R-019-BV to be ball valves with stellite balls and on-off rotary actuators.
4. P-011-CV through P-017-CV to have stellite seats and trim and to be sized for full pump capacity at set pressure.
5. All pumps, including standby pumps, to be equipped with local site and remote control module start/stop stations.
6. All remote control valves and remote block valves to be operable from both local site and remote control module locations.
7. All vessel level and pressure taps to be provided with internal baffles and intermittent water purges.
8. The pH sensor is to be a Uni-Loc Model 320P installed. The controller shall be adjustable over a pH range of 8 to 11.
9. All valves to be sized to handle the rates tabulated under Stream Properties in the 80% open position (actual capacity = 125% of specified capacity) except R-002-CV which is to be sized for the tabulated rate at 50% open, and R-003-CV which is to be sized for the tabulated rate at 100% open.
10. Controllers F-001-RC and F-003-RC shall be provided with remote set point capability.
11. All instrumentation shall be of the electronic type rather than pneumatic. Latest state of the art components shall be used.
12. All alarm conditions shall initiate an audible as well as visual alarms. The annunciator shall be equipped with both a test button and an acknowledge button to silence the audible signal without loss of visual alarm display.
13. Continuous two-pen recording of the O_2 and SO_2 analyzer output signals shall be provided at the stack gas monitoring station. These signals shall also be coupled to adjustable set point alarms to activate an alarm at the main control console.

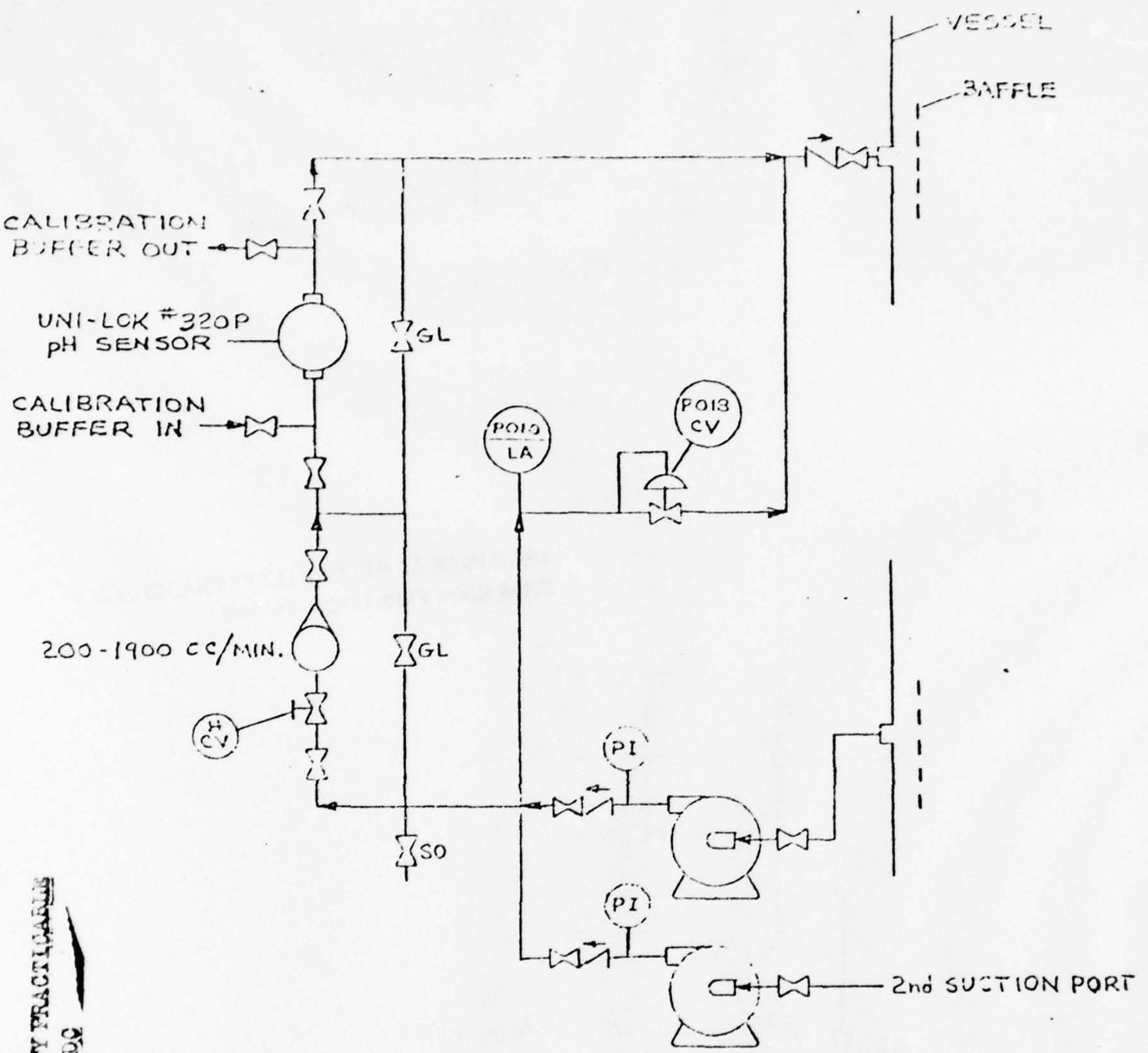


METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
LEVEL/PRESSURE TAP PURGE

EXXON RESEARCH AND ENGINEERING Co.

E.C.VATH / R.W.B.

DWG No. 1722-13-A



P-311 A + B
pH SAMPLE PUMPS
5 GPM EACH
ΔP = 15 PSI

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
pH SENSOR PIPING

EXXON RESEARCH AND ENGINEERING Co.

E C VATH / R.W.B.

DWG. No. 1722-12-A

(A) STEAM TRACED TEFLON SAMPLING LINE - DEKORON TYPE 2101

(B) REFRIGERATED GAS DRYER - HANKINSON

(C) KNOCKOUT TRAP

(D) GAS SAMPLING PUMP - DIA-VAC TYPE 277

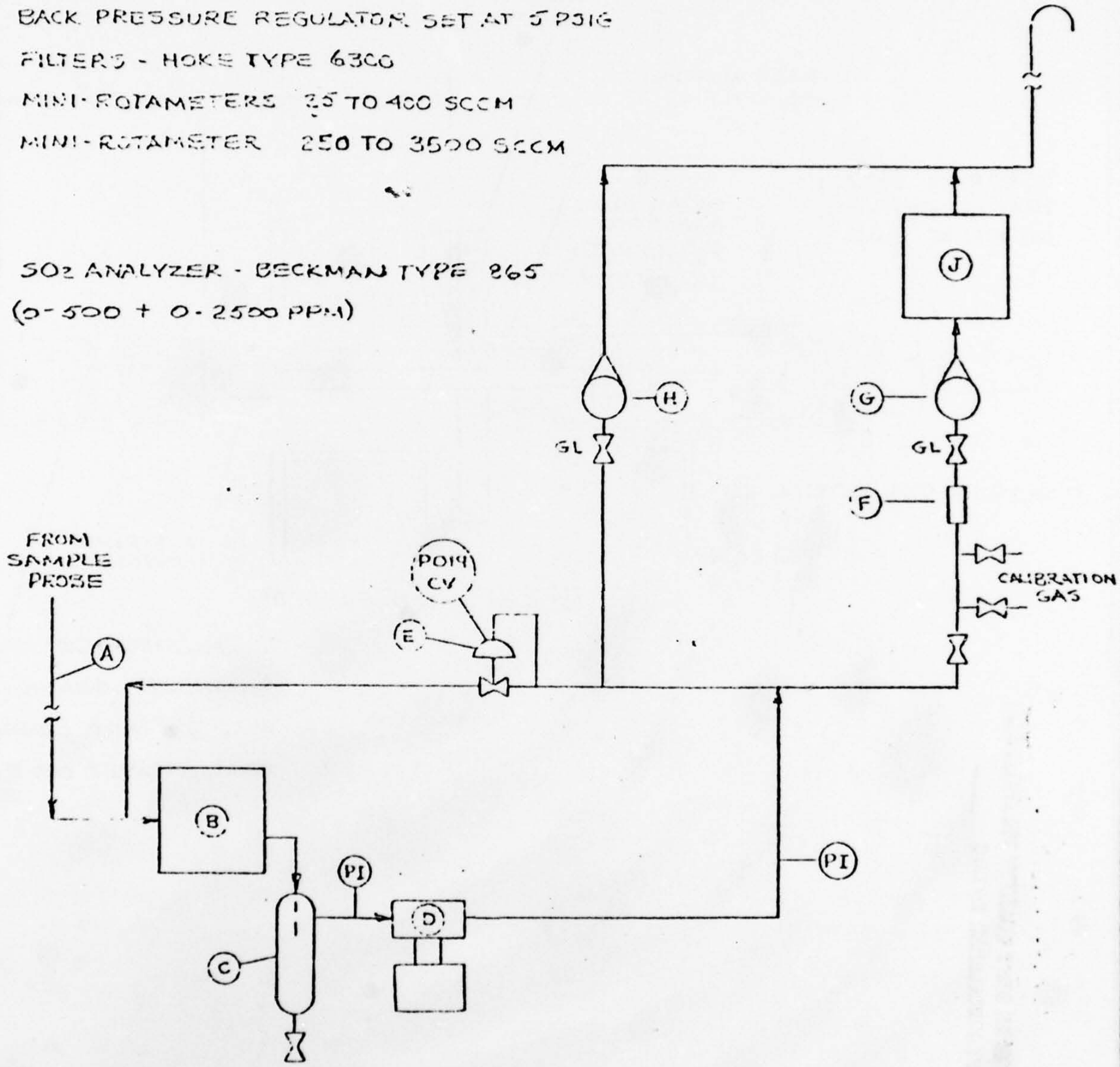
(E) BACK PRESSURE REGULATOR SET AT 5 PSIG

(F) FILTERS - HOKE TYPE 6300

(G) MINI-ROTAMETERS 35 TO 400 SCCM

(H) MINI-ROTAMETER 250 TO 3500 SCCM

(J) SO_2 ANALYZER - BECKMAN TYPE 865 (0-500 + 0-2500 PPM)



NOTES:

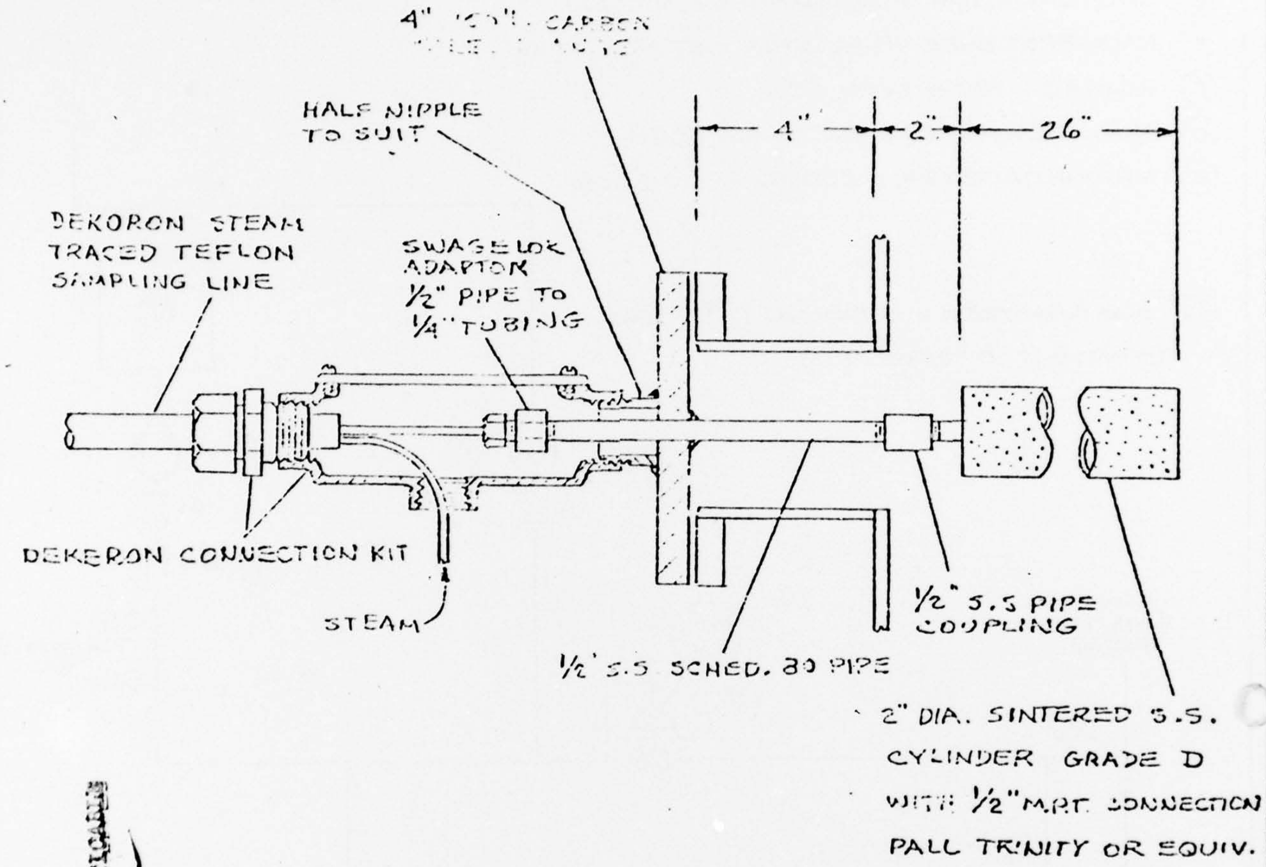
1. USE SPECIFIED COMPONENTS OR EQUIV.
2. ALL PROCESS WETTED COMPONENTS TO BE STAINLESS STEEL OR TEFLON.

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
STACK ANALYTICAL TRAIN

EXXON RESEARCH AND ENGINEERING CO.

E.C. VATH/R.W.B.

DWG. No. 1722- -A



METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
STACK SAMPLING PROBE

EXXON RESEARCH AND ENGINEERING Co.

DWG. No. 1722 - -A

APPENDIX

INSTRUMENT SYMBOLS

Letter	VARIABLE TYPES	FUNCTION CODES		
		Position-1	Position-2	Position-3
A	Analysis	Alarm	Alarm	Alarm
B	Burner Flame British Thermal Unit	Block		
C		Controller Control	Controller	Controller Control
(CI)			Cut In	Cut In
(CO)			Cut Out	Cut Out
D	Density Draft	Dial (Indicator) Dual (Interfaces)	Dial	
d		Differential		
E	Voltage	Element (Primary)		
F	Flow	Ratio (Fraction)		
G		Glass Gage		
H	Hand Actuated	High	High	
I	Current	Indicating Indicator	Indicating	
K	Time			
L	Level	Low	Low	
M	Note 1		Metal	
P	Pressure			
Q		Integrator	Integrator	Integrator
R	Radiation Remote	Recording (2) Recorder (Shared)	Recording (2) (Shared)	
S	Speed Safety	Switch	Switch	
T	Temperature			
V		Valve	Valve	Valve
W	Weight	Well		
X		Backup (3)	Backup (3)	Backup (3)
Z	Position (Displacement)			

Notes:
- (1) Variable type to be specified as required for individual project.
- (2) Where Pen is permanently connected to process variable, Recorder designated R.
- (3) Type of Automatic Backup to be specified.

APPENDIX

FLOW PLAN DESIGNATIONS

CLOSES ON OPERATING MEDIUM FAILURE Note (2)	1 FC	SAMPLE OUTLET, WITH COOLER	18 SO
OPENS ON OPERATING MEDIUM FAILURE Note (2)	2 FO	SAMPLE OUTLET, WITH HEATER	19 SO
OPENS ON OPERATING MEDIUM FAILURE, LOCKUP WITH LOCAL MANUAL RESET Note (2)	3 FOR	INTERLOCKED VALVES (Mechanical Type)	20 INT
CLOSES ON OPERATING MEDIUM FAILURE, LOCKUP WITH LOCAL MANUAL RESET Note (2)	4 FCR	"Y" TYPE STRAINER	21
REMAINS STATIONARY ON OPERATING MEDIUM FAILURE, BUT WITH SPRING ACTION IN OPENING DIRECTION Note (2)	5 FO(s)	HOSE CONNECTION (Size Must Be Specified)	22 HC
FLASHING SERVICE	6 FS	STEAM TRAP	23
CLOSES PORT HANDLING FLUID (shown by arrow) ON OPERATING MEDIUM FAILURE	7 FC	INSULATE FOR PROCESS	24 INS
BALL VALVE	8 B Note (1)	STEAM TRACE AND INSULATE	25
GLOBE VALVE	9 GL Note (1)	HEAT TRACE AND INSULATE (Other Than Steam)	26 H – TR
BUTTERFLY VALVE	10 BF Note (1)	INSTRUMENT LEADS (Type Not Specified)	27
DOUBLE DISC, SOFT SEAL, GATE VALVE WITH BODY BLEEDER	11 SS	VENTURI TUBE, OR FLOW NOZZLE	28
REMOTE BLOCK VALVE, (OPEN/CLOSE SERVICE) OPERATOR NOT SPECIFIED	12 R BV	ROTAMETER	29
REMOTE BLOCK VALVE, (THROTTLING SERVICE) OPERATOR NOT SPECIFIED	13 R CV	PITOT TUBE	30
HAND CONTROL VALVE (THROTTLING SERVICE)	14 H CV	COMPUTER INPUT OR FUNCTION	31
VALVE WITH FIGURE 8 BLIND	15	LEVEL (All types except Ball Float)	32
ANGLE VALVE	16	LEVEL (Ball Float Type)	33
SAMPLE OUTLET	17 SO	RESTRICTION ORIFICE	34 RO

Notes: (1) Add SS for soft seal.
(2) Operating medium is instrument air and instrument electrical power for electronic control loops with pneumatic control valves.

H. Effluent Gas Monitoring Station

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the Effluent Gas Monitoring Station as specified herein.

b. The station shall be installed by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The station will be installed within a protective enclosure. Ambient conditions within the shrouded area will range from 50 F during winter periods up to 110 F during summer operating periods.

d. The Effluent Gas Monitoring Station shall be transportable by railroad flat car. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	12 feet
Height	11 feet
Gross Weight	40 tons

Subcontractor shall arrange for any necessary special routing due to the wide load.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the

Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Components

a. Enclosure

The Effluent Gas Monitoring Station shall be housed in a 12' x 17' prefabricated steel structure designed from Drawing Sheet L-70. The walls will be bolted to the concrete floor provided by the prime Contractor. The floor shall have a floor drain and a sink drain. Steam heating and air conditioning units shall be located on the enclosure roof. The following utilities will be supplied by the prime Contractor:

Electric Power	30 amps at 240V, 60 Hertz
Water	1 gpm treated to be boiler feed water quality 30 psig
Compressed Air	30 scfm @ 100 psig
Steam	15 psig

In addition, the enclosure shall have:

1) Two (2) longitudinal rows of ceiling mounted flourescent lights.

2) Controlled room temperature between 60 F and 75 F when the outside ambient varies between 40 F in the winter and 110 F in the summer. The room temperature shall be controlled at 2 F from the setting.

3) Compressed air drier and filter to render high pressure air suitable for instrumentation.

4) Electrical outlet for a 1000 watt, 110 volt electric sample line heater.

5) One (1) 3'-7" door and five (5) windows, dimensions and locations per the drawing.

6) One (1) ladder for access to equipment on roof.

b. Internals

There shall be at least 30 feet of countertop, 24" wide. The countertop shall be flat and coated with a chemical resistant material. There shall be at least six (6) storage cabinets 24" wide containing a drawer and a larger area with a hinged door supporting the counter.

1) There will be basin at least 11" x 15" mounted in a matching countertop and a cold water tap.

2) Two (2) gas cylinder racks capable of holding three (3) cylinders will be wall mounted.

3) Ten (10) dual receptacle electrical outlets shall be mounted above the countertop. The receptacles shall be three (3) wire grounded type suitable for instruments.

4) Four (4) compressed air outlets with hand control valves shall be mounted above the countertop.

c. Monitoring Equipment

The Subcontractor shall provide in his design the following air pollution monitoring systems: Sulfur dioxide (SO_2), continuous oxygen (O_2). Each system shall be comprised of three main functional groups, the Sampling Transfer Line (STL), the Analyzer/Recorder Unit and the Alarm System. The STL shall transport continuous effluent gas samples from the sampling port No. 2 to the analyzer. The STL shall be designed to prevent sample condensation. The design and installation of the monitors shall be in accordance with applicable Environmental Protection Agency standards. The Analyzer/Recorder unit shall be located within the instrument room and shall process the gaseous samples to determine on a continuous basis (if possible) the concentration of pollutant in the effluent stream. The unit shall be capable of distinguishing the pollutant from other interference materials present in the sample and shall require a minimum of maintenance. The Analyzer/Recorder unit shall also provide a visual display and permanent record of the analysis. The Analyzer/Recorder shall be coupled to the Alarm System with an adjustable alarm set point. The Alarm System shall signal failures

in maintaining the established limits for the pollutants. The Alarm System shall activate a station on the annunciator of the main control panel.

1) The STL shall attach to a Subcontractor supplied flow average sample probe located in the system exhaust stack approximately 30 feet from the monitoring station. The STL shall be electrically heated to avoid condensation of the sample gases. The sample gases will have a dewpoint of approximately 165 F.

2) The SO_2 monitor shall be the latest state-of-the-art capable of monitoring 500 ppm SO_2.

3) The O_2 monitor shall be the latest state-of-the-art capable of monitoring 0-21% O_2.

4) Subcontractor shall supply necessary gas sample pretreatment apparatus.

I. Pumps

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver pumps as specified herein. The motors will be furnished by the prime Contractor.

b. Pumps shall be installed by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The pumps will be installed within a protective enclosure. Ambient conditions within the enclosed area will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods.

d. The pumps shall be transportable by railroad flat car.

e. The unit shall be shop tested prior to shipment to the installation site. Testing will consist principally of mechanical checks. Hydrostatic test on casing at 150% of working pressure.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

Pumps

NOTES:

1. Vapor pressure data cited for pure water at temperature disregarding effect of salt content.

2. NPSH and discharge pressure data based on negligible suction line pressure drop and minimum liquid filled heads as tabulated below. These figures should be reconsidered when final elevations and piping routes are established.

P-301	10 ft.	P-306 thru P-308	8 ft.
P-302	10 ft.	P-309	8 ft.
P-303	10 ft.	P-310	7 ft.
P-304	10 ft.	P-311	To suit
P-305	18 ft.		

3. Pump external flushing details to be specified by the construction contractor.

4. Pump motors to be sized to be not over nameplate rating for maximum power for impeller size specified and furnished.

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

NUMBER	P-301 A + B	P-302 A + B
NAME	Purge Pumps	Quench Brine Pumps
GENERAL TYPE	Centrifugal	Centrifugal
PROCESS REQUIREMENTS		
FLUID PUMPED	Caustic salt solution	Caustic salt solution
RATED PUMPING TEMP., °F	160	160
SP. GRAVITY @ P.T.	1.16	1.16
VISCOSITY @ P.T., CP	1.2 @ 160°F.	1.2 @ 160°F.
VAPOR PRESS., @ P.T., PSIA	4.74 (1)	474 (1)
AVAIL. NPSH @ PUMP	25 Minimum (2)	25 Minimum (2)
CENTERLINE, FT.		
RATED CAPACITY @ P.T., GPM	40	60
DISCHARGE PRESSURE, PSIG	27 (2)	27 (2)
DIFFERENTIAL PRESSURE, PSI	26	26
SOLIDS	0.5 wt. %	0.5 wt. %
	Size Distribution:	Size Distribution:
	63% < 5 microns	63% < 5 microns
	39% < 2 microns	39% < 2 microns
DESIGN AND CONSTRUCTION		
DRIVER TYPE	Electric Motor 1 hp	Electric Motor 2 hp
CASING DESIGN TEMP., °F	200	200
CASING DESIGN PRESS., PSIG	100	100
MATERIAL CLASS OR	Ni-Resist Casing-Monel	Ni-Resist Casing-Monel
MATERIALS	Impeller and Internals	Impeller and Internals
SEAL TYPE	Double mechanical	Double mechanical
FLUSHING SYSTEM	External	External
	Slurry Construction	Slurry Construction

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

NUMBER	P-303 A + B	P-304 A + B
NAME	Quench Brine Return Pumps	Slurry Pumps
GENERAL TYPE	Centrifugal	Centrifugal
PROCESS REQUIREMENTS		
FLUID PUMPED	Caustic Salt Solution	Caustic Salt Solution
RATED PUMPING TEMP., °F	160	160
SP. GRAVITY @ P.T.	1.16	1.16
VISCOSITY @ P.T., CP	1.2 @ 160°F.	1.2 @ 160°F.
VAPOR PRESS., @ P.T., PSIA	4.74 (1)	4.74 (1)
AVAIL. NPSH @ PUMP	25 Minimum (2)	25 Minimum (2)
CENTERLINE, FT.		
RATED CAPACITY @ P.T., GPM	75	320
DISCHARGE PRESSURE, PSIG	22 (2)	30 (2)
DIFFERENTIAL PRESSURE, PSI	21	28
SOLIDS	0.5 wt. %	0.5 wt. %
	Size Distribution:	Size Distribution:
	63% < 5 microns	63% < 5 microns
	39% < 2 microns	39% < 2 microns
DESIGN AND CONSTRUCTION		
DRIVER TYPE	Electric Motor 3 hp	Electric Motor 7.5 hp
CASING DESIGN TEMP., °F	200	200
CASING DESIGN PRESS., PSIG	100	100
MATERIAL CLASS OR	Ni-Resist Casing - Monel	Ni-Resist Casing - Monel
MATERIALS	Impeller and Internals	Impeller and Internals
SEAL TYPE	Double mechanical	Double mechanical
FLUSHING SYSTEM	External	External
	Slurry Construction	Slurry Construction

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

NUMBER	P-305 A + B	P-306, P-307, P-308
NAME	Clean Liquor Pumps	Product Pumps
GENERAL TYPE	Centrifugal	Centrifugal
PROCESS REQUIREMENTS		
FLUID PUMPED	Caustic Salt Solution	Caustic Salt Solution
RATED PUMPING TEMP., °F	160	160
SP. GRAVITY @ P.T.	1.16	1.16
VISCOSITY @ P.T., CP	1.2 @ 160°F.	1.2 @ 160°F.
VAPOR PRESS., @ P.T., PSIA	4.74 (1)	4.74 (1)
AVAIL. NPSH @ PUMP CENTERLINE, FT.	25 Minimum (2)	25 Minimum (2)
RATED CAPACITY @ P.T., GPM	300	30
DISCHARGE PRESSURE, PSIG	26 (2)	26 (2)
DIFFERENTIAL PRESSURE, PSI	20	26
SOLIDS	400 ppm all less than 1 micron	0.5 wt. %
		Size Distribution:
		63% < 5 microns
		39% < 2 microns
DESIGN AND CONSTRUCTION		
DRIVER TYPE	Electric Motor 5 hp	Electric Motor .75 hp
CASING DESIGN TEMP., °F	200	200
CASING DESIGN PRESS., PSIG	100	100
MATERIAL CLASS OR MATERIALS	N1-Resist Casing - Monel Impeller and Internals	N1-Resist Casing - Monel Impeller and Internals
SEAL TYPE	Double mechanical	Double mechanical
FLUSHING SYSTEM	External	External
	Slurry Construction	Slurry Construction

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

UMBER	P-309 A + B	P-310 A + B
AME	Salt Dryer Feed Pumps	Caustic Pumps
ENERAL TYPE	Centrifugal	Centrifugal
ROCESS REQUIREMENTS		
LUID PUMPED	Caustic Salt Soltuion	Caustic
ATED PUMPING TEMP., °F	160	110
P. GRAVITY @ P.T.	1.16	1.20
ISCOSITY @ P.T., CP	1.2 @ 160°F.	2.0 @ 110°F./3.7 @ 70°F.
APOR PRESS., @ P.T., PSIA	4.74 (1)	1.27 (1)
VAIL. NPSH @ PUMP	25 Minimum (2)	25 Minimum (2)
CENTERLINE, FT.		
ATED CAPACITY @ P.T., GPM	90	20
ISCHARGE PRESSURE, PSIG	26 (2)	27
IFFERENTIAL PRESSURE, PSI	26	26
OLIDS	0.5 wt. %	None
	Size Distribution:	
	63% < 5 microns	
	39% < 2 microns	
ESI AND CONSTRUCTION		
RIVER TYPE	Electric Motor 3 hp	Electric Motor .75 hp
ASING DESIGN TEMP., °F	200	150
ASING DESIGN PRESS., PSIG	100	100
ATERIAL CLASS OR	Ni-Resist Casing - Monel	Carbon Steel - Teflon Seals
MATERIALS	Impeller and Internals	
EAL TYPE	Double Mechanical	Double Mechanical
LUSHING SYSTEM	External	Self-flushed
	Slurry Construction	

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

NUMBER	P-311 A + B	P-312
NAME	pH Sample Pumps	Drier Brine Return
GENERAL TYPE	Centrifugal	Centrifugal
PROCESS REQUIREMENTS		
FLUID PUMPED	Caustic Salt Solution	Caustic Salt Solution
RATED PUMPING TEMP., ^{o}F.	160	150
SP. GRAVITY @ P.T.	1.16	1.16
VISCOSITY @ P.T., CP	1.2 @ 160^{o}F.	1.2 @ 160^{o}F.
VAPOR PRESS., @ P.T., PSIA	4.74 (1)	4.74
AVAIL. NPSH @ PUMP CENTERLINE, FT.	25 Minimum (2)	Flooded Suction
RATED CAPACITY @ P.T., GPM	5	150
DISCHARGE PRESSURE, PSIG	Based on elevation	Atmospheric
DIFFERENTIAL PRESSURE, PSI	15	15
SOLIDS	0.5 wt. % Particle Size: 63% less than 5 microns 39% less than 2 microns	1.0 wt. %
DESIGN AND CONSTRUCTION		Submerged Pump
DRIVER TYPE	Electric Motor .5 hp	Electric Motor 3 hp
CASING DESIGN TEMP., ^{o}F.	200	200
CASING DESIGN PRESS., PSIG	50	50
MATERIAL CLASS OR MATERIALS	Hastelloy C - Teflon Seals	Stainless Steel - Teflon
SEAL TYPE	Mechanical	
FLUSHING SYSTEM	Self flushed	Self flushed
		Vendor to quote duplex system package and alternator and float switch, high level alarm and common pit cover

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

UMBER	P-313 A&B	P-314
AME	Fuel Oil Supply Pumps	Boiler Fuel Oil Pump
ENERAL TYPE	Rotary	Rotary
ROCESS REQUIREMENTS		
LUID PUMPED	#2 Fuel Oil	#2 Fuel
ATED PUMPING TEMP., °F.		
P. GRAVITY @ P.T.	.85	.85
ISCOSITY SAYBOLT SEC.	170	170
APOR PRESS., @ P.T., PSIA		
VAIL. NPSH @ PUMP CENTERLINE, FT.		
ATED CAPACITY @ P.T., GPM	2	4 g.p.m.
ISCHARGE PRESSURE, PSIG	400 p.s.i.g.	100 p.s.i.g.
IFFERENTIAL PRESSURE, PSI	400 p.s.i.	100 p.s.i.
OLIDS	Nil	Nil
ESIGN AND CONSTRUCTION		
RIVER TYPE	Electric Motor .5 hp	Electric Motor 1 hp
ASING DESIGN TEMP., °F.	150°	150°
ASING DESIGN PRESS., PSIG	150	150
ATERIAL CLASS OR MATERIALS	Brass	Brass
EAL TYPE	Mechanical	Mechanical
LUSHING SYSTEM	Self flush	Self flush

Explosion proof electrical vendor to quote duplex system package including float switch, alternator high level alarm and common pit cover

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

UMBER	P-315 A&B	P-316
AME	Boiler Feed Water	Boiler Condensate Return
ENERAL TYPE	Turbine	Turbine
ROCESS REQUIREMENTS		
LUID PUMPED	Water	Water
ATED PUMPING TEMP., °F.	210°	210°
P. GRAVITY @ P.T.	1.0	1.0
ISCOSITY @ P.T., CP	1.0	1.0
APOR PRESS., @ P.T., PSIA	4.74	4.74
VAIL. NPSH @ PUMP CENTERLINE, FT.	25 Minimum	25 Minimum
ATED CAPACITY @ P.T., GPM	20	40
ISCHARGE PRESSURE, PSIG	125	10
IFFERENTIAL PRESSURE, PSI	125	10
OLIDS	Nil	Nil
ESIGN AND CONSTRUCTION		
RIVER TYPE	Electric Motor 15 hp	Electric Motor .75 hp
ASING DESIGN TEMP., °F.	250	250
ASING DESIGN PRESS., PSIG	150	150
ATERIAL CLASS OR MATERIALS	Brass	Brass
EAL TYPE	Mechanical	Mechanical
LUSHING SYSTEM	Self flush	Self flush

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

IBER	P-317	P-318 A&B
IE	Treated Water Pump	Floor Wash Sump Pump
IERAL TYPE	Turbine	Vertical Sump Pumps
)CESS REQUIREMENTS		
JID PUMPED	Water	Caustic Acid Salts
ŒD PUMPING TEMP., °F.	100	150
. GRAVITY @ P.T.	1.0	1.2
;COSITY @ P.T., CP	1.0	1.2
'OR PRESS., @ P.T., PSIA	4.74 (1)	4.74 (1)
\IL. NPSH @ PUMP CENTERLINE, FT.	25 Minimum	Flooded Inlet
ŒD CAPACITY @ P.T., GPM	20	90
;CHARGE PRESSURE, PSIG	50	10
'FERENTIAL PRESSURE, PSI	40	10
.IDS	Nil	1.0% wt.
;IGN AND CONSTRUCTION		Submerged Pump
IVE TYPE	Electric Motor .5 hp	Electric Motor 2 hp
;ING DESIGN TEMP., °F.	150	200
;ING DESIGN PRESS., PSIG	100	25
ŒRIAL CLASS OR MATERIALS	Brass	Stainless Steel - Teflon
\L TYPE	Mechanical	
JSHING SYSTEM	Self flush	

PUMP DATA SHEET

EXXON RESEARCH AND ENGINEERING COMPANY

NUMBER	P-319		
NAME	Reverse Osmosis Feed		
GENERAL TYPE	Multi-Stage Centifugal		
PROCESS REQUIREMENTS			
FLUID PUMPED	Water		
RATED PUMPING TEMP., ^{o}F.	100		
SP. GRAVITY @ P.T.	1.0		
VISCOSITY @ P.T., CP	1.0		
VAPOR PRESS., @ P.T., PSIA			
AVAIL. NPSH @ PUMP CENTERLINE, FT.	25		
RATED CAPACITY @ P.T., GPM	21		
DISCHARGE PRESSURE, PSIG	600		
DIFFERENTIAL PRESSURE, PSI	610		
SOLIDS	Nil		
DESIGN AND CONSTRUCTION			
DRIVER TYPE	Electric Motor 15 hp		
CASING DESIGN TEMP., ^{o}F.	200		
CASING DESIGN PRESS., PSIG	750		
MATERIAL CLASS OR MATERIALS	Bronze		
SEAL TYPE	Mechanical		
FLUSHING SYSTEM	Self Flush		

J. Blowers

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver blowers as specified herein.

b. The blowers shall be installed by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The blowers will be installed within a protective enclosure. Ambient conditions within the area will range from 50 F up to 200 F during operating periods.

d. The blowers shall be transportable by railroad flat car.

e. The blowers shall be shop tested prior to shipment to the installation site. Testing will consist principally of mechanical checks.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication.

Written approval will be provided by the designated representative of the prime Contractor.

5. Combustion Air Supplies

Blowers 351 A and B supply combustion air to the burners in the furnace, PFB, and AFB. The blowers will be located within the 6 change per hour area adjacent to the furnace so all of their combustion air is drawn from the shrouded area. Each blower is capable of producing 60% of the total air requirement, so both blowers will be functioning whenever the furnace is operating. In case of a blower failure, the furnace will shut down and then the remaining blower will be able to supply the PFB and AFB.

The PFB combustion air fan (B 352 A and B) supply the air to burn the volatilized Mustard. The primary blower will be actuated from a temperature controller sensing the PFB temperature. In case of blower failure, the back-up blower will be actuated.

The combustion air blowers for the stack reheater and boiler will be separate. They will not draw air from the shrouded area.

The combustion air system is shown schematically on Concept Design Drawing, Sheet L-57.

6. Specifications

a. Centrifugal fans to be Arrangement 1, V-belt driven.

b. Flanged inlet and flanged outlet on centrifugal and axial fans.

c. V-belt drives to have OSHA approved guard.

METAL PARTS FURNACE
DAAA15-74-C-0092

BLOWER SPECIFICATION SHEET

Number	BL 350	BL 351 A&B
Name	Scrubber Induced Draft	Furnace Combustion Air
General Type	Centrifugal	Centrifugal
Inlet Volume, acfm	20,000	1,425
Inlet Pressure, psia	10.55	12.0
Inlet Temperature, ^{o}F	165	200
Differential Pressure, "w.c.	40	38
Gas Analysis		
N_2	52.1	78.6
O_2	7.6	20.9
CO_2	3.5	
H_2O	37.8	0.5
Corrosives	Trace $SO_2/HCl/P_2O_5/NaOH$	
Materials	Epoxy Coated Steel	Steel
Drive Type	2 Speed Electric Motor 150 hp	Electric Motor 40 hp

FORM GEN - 51

METAL PARTS FURNACE
DAAA15-74-C-0092

BLOWER SPECIFICATION SHEET

Number	BL 352 A&B	BL 353
Name	PFB Combustion Air	Furnace Sparge Air
General Type	Centrifugal	Reciprocating
Inlet Volume, acfm	5,080	5
Inlet Pressure, psia	12.0	12.0
Inlet Temperature, ^{o}F	200	70
Differential Pressure, "w.c.	18	60 psig
Gas Analysis		
N_2	78.6	78.6
O_2	20.9	20.9
CO_2		
H_2O	0.5	0.5
Corrosives		
Materials	Steel	Steel
Drive Type	Electric Motor 10 hp	Electric Motor .75 hp

Form Gen - 81

METAL PARTS FURNACE
DAAA15-74-C-0092

BLOWER SPECIFICATION SHEET

Number	BL 354 A&B	BL 355 A&B
Name	Air Cooling Station	Boiler Combustion Air
General Type	Tube Axial	Centrifugal
Inlet Volume, acfm	9,760	2,100
Inlet Pressure, psia	11.96	12.0
Inlet Temperature, ^{o}F	150	70
Differential Pressure, "w.c.	1.0	18
Gas Analysis		
N_2	78.6	78.6
O_2	20.9	20.9
CO_2	0.5	
H_2O		0.5
Corrosives	Trace HCl/SO_2	
Materials	Steel	Steel
Drive Type	Electric Motor 5 hp	Electric Motor 10 hp

METAL PARTS FURNACE
DAAA15-74-C-0092

BLOWER SPECIFICATION SHEET

Number	BL 356	BL 357
Name	Control House Ventilation	Dryer Ventilation
General Type	Axial Flow	Axial Flow
Inlet Volume, acfm	250	8,000
Inlet Pressure, psia	11.996	11.992
Inlet Temperature, ^{o}F	70	170
Differential Pressure, "w.c.	0.1	0.25
Gas Analysis		
N_2	78.6	47.5
O_2	20.9	12.5
CO_2		
H_2O	0.5	40
Corrosives	Trace SO_2/HCl	Trace Sodium Salts as particulates
Materials	Steel	Stainless
Drive Type	Electric Motor .5 hp	Electric Motor 1 hp

FORM GEN - 81

METAL PARTS FURNACE
DAAA15-74-C-0092

BLOWER SPECIFICATION SHEET

Number	BL 358	BL 359
Name	Dryer Knife Dust	Stack Reheater Combustion Air
General Type	Centrifugal	Centrifugal
Inlet Volume, acfm	3000	190
Inlet Pressure, psia	11.8	12.0
Inlet Temperature, ^{o}F	100	70
Differential Pressure, "w.c.	5.0	18
Gas Analysis		
N_2	78.2	78.6
O_2	20.8	20.9
CO_2		
H_2O	1.0	0.5
Corrosives	Trace Sodium Salts as particulates	
Materials	Steel	Steel
Drive Type	Electric Motor 5 hp	Electric Motor 3 hp

FORM GEN - 81

K. Stack Reheater

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the stack reheat burner subassembly as specified herein.

b. The stack reheater subassembly shall be erected by the Government's prime Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The fan will be installed within a protective enclosure. Ambient conditions within the enclosed area will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods.

d. The stack reheater subassembly shall be transportable by railroad flat car. Flanged subassembly breakdown shall be approximately as shown on the Concept Design Drawing, sheet L-41. The subassembly, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

e. The unit shall be shop tested prior to shipment to the installation site. Testing will consist principally of firing the burner. The test fuel shall be with No. 2 fuel oil.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessi-

bility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

Burners

Reheat Burner

Fuel	#2 Fuel Oil
Maximum Firing Rate, GPM	0.5
Maximum Heat Fired, BTU/HR.	4.2×10^6
Ambient Make-Up Air	Saturated @ 70°F. and 12.0 PSIA
Entering Gas Oxygen Content, Vol. %	8.6
Entering Gas Velocity, FT/SEC.	96
Entering Gas Temperature, °F.	155
Burner Zone Pressure, PSIA	10.7
Duty	Continuous
Power Available	120V-1Ø-60 Cycle
Steam Pressure Available, PSIG	125
Location	Indoor

Notes:

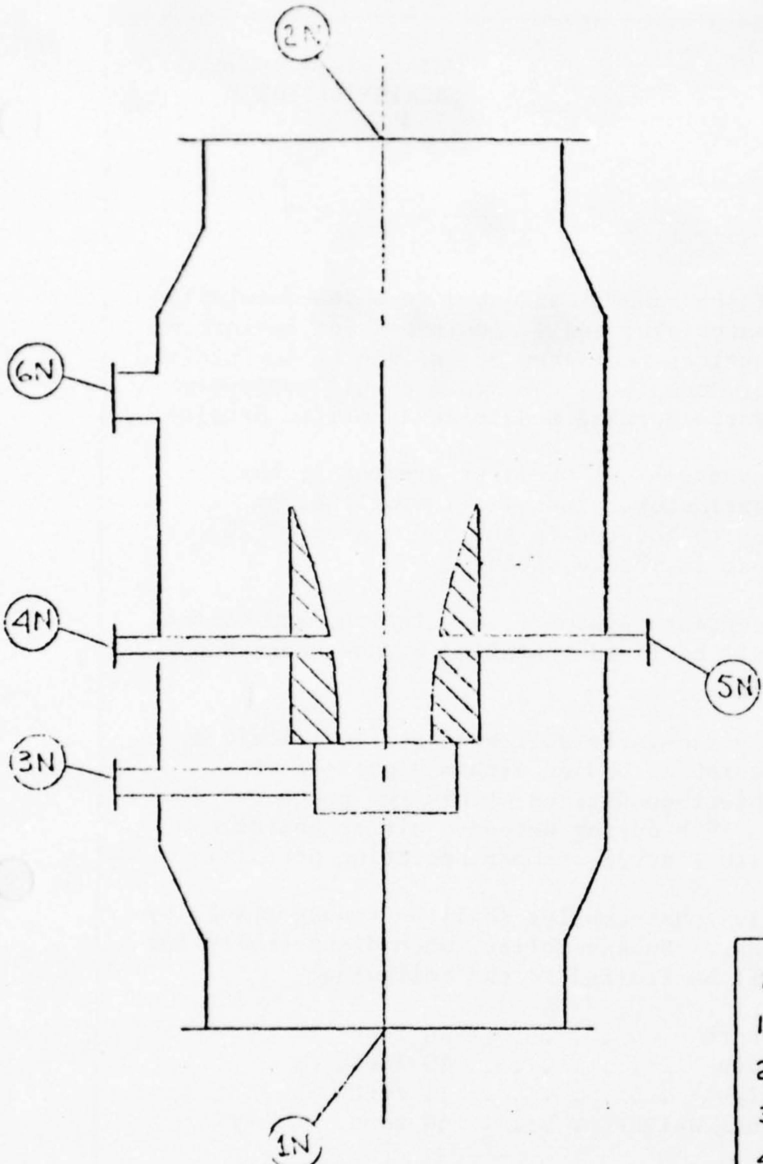
1. The burner shall be fabricated as a replaceable section of the 30 inch diameter stack.

2. The burner chamber shall be refractory lined. No cooling water will be provided.

3. The ambient make-up air rate shall be interlocked to the fuel oil firing rate so as to maintain no visible combustion products. (Approximately 25% of stoichiometric).

4. The burner design is to provide for a minimum 3 to 1 turndown and shall be adjustable from the control module up to 200 ft. from the burner site.

5. Automatic flame safeguard controls and alarms shall be provided as a part of the burner package to shut off the burner fuel in the event of ignition failure, flame failure, high or low fuel pressure, or high combustion chamber temperature. Appropriate alarms and indicators shall be provided at the remotely located control module.



No.	SERVICE	SIZE
1 N	GAS INLET	30"
2 N	GAS OUTLET	30"
3N	OIL GUN/AIR INLET	
4N	PILOT IGNITOR	
5N	FLAME-OUT DETECTOR	
6N	SIGHT PORT	

METAL PARTS FURNACE
AIR POLLUTION CONTROL SYSTEM
REHEAT BURNER

EXXON RESEARCH AND ENGINEERING Co.

E.C.VATH / RWB.

DWG. No. 1722-10-A

L. Steam Supply

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the steam supply subsystem for the Metal Parts Furnace Module as specified herein.

b. Steam supply subassemblies shall be erected by the Installation Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. Steam piping, condensate piping, insulation, and control installation will be field installed by the steam supply subcontractor(s).

d. The steam supply subsystem will be installed within a shrouded area which is housed within a protective enclosure. Ambient conditions within the protected area will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods.

e. The steam supply subassemblies shall be transportable by railroad flat car. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

f. The boiler unit shall be shop tested prior to shipment to the installation site. Testing will consist principally of firing the burner and pressure testing the steam generation unit. The test fuel shall be No. 2 fuel oil.

g. The steam supply piping subsystem shall be field tested. Testing will include a hydrostatic pressure test of not less than 300 psi for a period of two hours. All defects disclosed as a result of this test shall be remedied and defective work or materials shall be replaced and tests repeated. All repairs shall be made with new materials and no caulking of screwed joints, holes or cracks will be acceptable.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Description

The steam supply system is shown schematically on the Concept Design Drawing, Sheet L-58. Components are further described as follows:

a. Boiler

Contractor will furnish one (1) York-Shipley No. 576 or equal boiler rated at 300 hp. The boiler will produce approximately 10,350 pounds of steam at approximately 125 pounds per square inch. E.D.R. square foot gross steam equals 41,875. The boiler will be complete with a gas-tight front and rear smoke box assembly.

1) The boiler will be powered by forced draft oil burners firing No. 2 fuel oil.

2) The tubes will be of heavy gauge material.

3) The outer shell complete with an 11" x 15" ASME manhole and lifting lugs.

4) Two inch (2") of insulation and metal jacket will encase the outer shell.

5) The boiler will be designed to meet the state and local codes of the State of Utah for a nominal rating of 5 sq ft per boiler horsepower.

6) The boiler will be equipped with a front clean-out door, large furnace volume, and sturdy steel fabricated base.

7) The boiler will be designed to ASME standards for three (3) pass boilers.

8) The unit will be completely factory assembled and tested carrying the U.L. label.

9) The unit will meet the standards of FIA and FM.

10) Floor space provided including tube removal will be approximately 33'-0" x 8'-3".

b. Condensate Receiver

Contractor will furnish one (1) Aurora duplex condensate receiver (or equal) consisting of a 350 gallon receiver tank and two (2) pumps (one is for standby).

1) The tank will be 3/16" galvanized inside and out. The receiver includes two outlets, drain and connections for optional equipment. A brass float valve is provided with simple level action replacing water loss due to process losses, etc. The unit will be capable of receiving temperatures to 210 F water and selected for a minimum capacity of twice the rate of evaporation.

2) A pressure water level gauge glass assembly will be supplied complete with shutoff valve and protector rods. A 3-way valve provides dependable operation. With a turn of plug the water flow can be channeled through the strainer or bypassed around the strainer (to allow the strainer to be cleaned) or completely shut off.

3) Interchangeable design provides for future system expansion with receiver connections for up to three pumps.

4) The unit will be completely assembled including the piping from receiver to pump including the expansion type elbows.

5) All pumps and piping will be mounted beneath the receiver and within the support stand.

6) The pumps are to be designed for 150 lbs/in^2 boiler feed water application.

7) A make-up feeder valve is to be provided.

8) The unit will meet 150 lb ASME Code for receivers.

9) Magnesium anode will provide electrolytic corrosion protection.

10) The unit will be complete with a pre-wired control panel to both integral 15 hp motors and includes external reset buttons and hand-off-automatic switches.

11) An electrical alternator will be supplied, mounted, and wired.

12) Floor space provided for the total unit will be approximately 4'-0" x 6'-6".

c. Pressure Reducing Station

Contractor shall provide a pressure reducing station to reduce 125 psi steam from the boiler to 15 psi for heating equipment. The reducing station shall be sized to handle a rated steam flow of 1100 lbs per hour.

1) The unit will have a design factor of 125% rated flow.

2) Pressure indicators will be mounted both upstream and downstream of the regulator.

3) The regulator shall modulate the pressure over a range of 5:1 turndown.

d. Steam Piping

Steam piping will be field installed to serve the following user items:

1) Drum dryers (125 psi)

2) Brine retention tanks (15 psi)

3) Scrubber enclosure heaters (15 psi)

4) Brine treatment enclosure heaters (15 psi)

5) Furnace process control (125 psi)

e. Condensate Piping

Condensate return piping will connect steam traps on user equipment to the condensate receiver.

6. Standard Specification for Steam Piping, 0-150 psi

a. Pipe

1) All sizes, seamless carbon steel ASTM Specification A53 Grade "A", or A-106, Grade "A" for cold bending.

2) 6" and below, schedule 80.

3) 8" and above, 1/2 wall thickness.

b. Gate Valves

1) 2 1/2" and larger - Crane No. 33XR, or approved equal, 300 lb cast steel, flanged OS&Y.

2) 2" and under - 600 lb steel, screwed, Vogt No. 5-9858 to 5-9851, or approved equal.

c. Globe Valves

1) 2 1/2" and larger - Crane No. 151XR, or approved equal, cast steel, flanged.

2) 2" and under - 300 lb steel, screwed, Vogt No. 12188 to 12181, or approved equal.

d. Check Valves

1) 2 1/2" and larger - Crane No. 159X, or approved equal, cast steel, flanged swing check.

2) 2" and under - 300 lb bronze, swing check, screwed, Walworth No. 428, or approved equal.

e. Fittings - Steel

1) 2 1/2" and up - extra strong steel butt-welding - ASTM Specification A-234.

2) 2" and under - 3000 lb forged steel, socket welding, ASTM A-105, Grade 2, except at valves, traps, strainers and control equipment shall be screwed.

f. Gaskets

1/16" comp. asbestos material, ring gasket, Garlock No. 901, or approved equal.

g. Bolts

1" and under - coarse continuous threaded stud bolt to comply with ASTM Specification A193, Grade B7, threads ASA B-1.4.

h. Unions

2" and under - screwed unions, ground ball joints, bronze to bronze seats, "Dart" 300 lb, or approved equal.

i. Nuts - Alloy Steel, Specification ASTM A-194, Grade 3 or 4, ASA No. B-1.4

1) 1" and smaller with thread series.

2) 1 1/8" and larger with 8 pitch thread series.

j. Flanges

Welding neck flanges, 300 lb, F&D with 1/16" raised face, forged steel, ASTM A-181 - Grade 1.

Note: Remove 1 1/6" raised face when connecting to semi-steel machinery flanges.

1) All risers shall be trapped. Traps placed every 250 ft on runs. All end piping and lowest points to be trapped.

2) Slope lines 1/16" per foot.

3) For trap specifications see "m".

k. Underground steam lines to be run in conduit equal to Ric-Wil Co.

l. Condensate

All condensate lines and trap discharge lines, including valves and fittings shall be of the same specifications as the pressure group of steam lines they serve.

m. Steam Traps and Strainers

1) For steam tracing and instrumentation service - 0-250 psi - Armstrong 800 series with internal strainer and check valve, or approved equal.

2) For steam mains, unit heaters and process heating - traps 0-250 psi - Armstrong 200 series, screwed with internal check valve, or approved equal.

Strainers - 2" and smaller - Armstrong semi-steel, screwed "Y" type strainer, or approved equal.

2 1/2" and larger - Armstrong carbon steel, flanged, 300 lb "Y" type strainer, or approved equal.

3) Installation - Traps are to be installed at all low points in steam mains at the end of main and branch runs of steam piping and shown on detail drawings.

All traps on process equipment are to have suitable by-passes for use in case of trap failure. All bypasses must be approved by the Contracting Officer.

Traps are to be selected on the basis of capacity and service requirements.

High points must have suitable vent valves.

7. Class "B" Insulation

Specification (150 lb steam)

a. Pipe Insulation

All pipe covering under this classification shall be lime and silica (Owens-Corning "Kaylo" or approved equal), and shall be of the thickness as outlined in the following table.

Sectional covering shall be used up to and including 10" pipe size. Pipe sizes 12" and over shall have segmental block covering of proper radius for the pipe. Blocks shall be fastened in place with loops of 16 gauge black annealed iron wire drawn tight and spaced at not greater than 9" centers. All joints in the blocks shall be filled and pointed up with asbestos cement.

b. Pipe Bends

Pipe bends shall be covered with the same type and thickness of pipe covering as straight pipe.

The covering shall be mitered to the proper radius of the bend, each segment well wired in place, all joints filled with asbestos cement and the outer surface of the segments coated with asbestos cement. The finishing coat of cement shall be troweled smooth and to the true radii of both the pipe and bend. Only enough asbestos cement shall be used to properly curve the finish coat and it shall be feather edged onto the adjacent straight pipe covering.

c. Fittings, Valves, Tube Turns, Drip Legs, Etc.

All fittings, valves, tube turns, etc., up to and including 3" pipe size shall be covered with a first quality mineral wool cement equal in thickness to the adjacent pipe covering. This cement shall be applied in one-half inch coats, each coat allowed to dry before the following coat is applied. The finish coat shall be 1/4" asbestos cement troweled smooth.

All fittings, valves, etc., 4" and larger pipe size shall be covered with blocks of the same thickness as the adjacent pipe covering and shall be well wired in place. All joints in the blocks shall be filled with asbestos cement and the outer surface coated with asbestos cement troweled to a smooth finish.

d. Flanges

All flanges shall be covered with blocks of the same thickness as adjacent pipe covering wired in place with 16 gauge black iron wire. All joints in the blocks shall be filled and pointed up with asbestos cement. The outer surface of the blocks shall be coated with a good coat of asbestos cement.

All flange covering blocks shall extend over adjacent pipe covering not less than 2" and where required to make a tight joint shall be bonded to the pipe covering with asbestos cement.

All flanges must be covered separately and in such a manner that when necessary to open up a flange cover, the adjacent fitting, flange or pipe covering will not be disturbed. The Contractor shall submit a drawing for our approval, showing the type of flange cover to be supplied.

Flange covers must have square edges and the cement finish must be troweled to a true radius, and sides of the covers shall be parallel to each other and plumb.

e. Insulation Table

Pipe Size	Nominal Thickness
1/2"	1"
3/4"	1"
1"	1"
1 1/4"	1 1/2"
1 1/2"	1 1/2"
2"	1 1/2"
2 1/2"	1 1/2"
3"	2"
4"	2"
6"	2 1/2"
8"	3"
10"	3"
12"	3 1/2"
14"	3 1/2"
16"	3 1/2"

8. Class "C" Insulation

Low pressure steam

a. Pipe Insulation

All piping in this classification shall be covered with standard thickness lime and silica pipe covering (Owens-Corning "Kaylo," or approved equal), in accordance with the following thickness table.

Sectional covering shall be used up to and including 10" pipe size. Pipe sizes 12" and over shall have segmental block covering of proper radius for the pipe. Blocks shall be fastened in place with loops of 16 gauge black annealed iron wire drawn tight and spaced at not greater than 9" centers. All joints in the blocks shall be filled and pointed up with asbestos cement.

b. Pipe Bends

All pipe bends shall be covered with standard thickness of covering mitered to the radius of the bend. Each segment shall be wired in place, all joints between segments filled with asbestos cement, and the outer surface finished with a coat of asbestos cement. The finish coat of cement shall be troweled smooth and shall be of sufficient thickness to permit troweling of true radii.

c. Fitting, Valves, Separators, Etc.

All fittings, valves, etc., up to and including 6" pipe size shall be covered with a high grade mineral wool cement to a thickness equal to that of the adjacent pipe covering. The finish coat of cement shall be a one-quarter inch coat of asbestos cement troweled to a smooth finish. All fittings, valves, etc., 8" pipe size and over shall be covered with 1" thick lime and silica blocks, well aired on and finished with a good coat of asbestos cement troweled smooth.

e. Insulation Table

Pipe Size	Nominal Thickness
1/2"	1"
3/4"	1"
1"	1"
1 1/4"	1"
1 1/2"	1"
2"	1"
2 1/2"	1"
3"	1"
4"	1"
6"	1 1/2"
8"	1 1/2"
10"	1 1/2"
12"	2"
14"	2"
16"	2"
18"	2"
20"	2"

9. Class "F" Insulation (Condensate Receiver)

Hot water heaters

Boiler feed water heaters

Condensate receivers

Flash tanks, etc.

The boiler feed water heater, flash tanks, etc., shall be covered with 1 1/2" thick, 85% carbonate of magnesia blocks or equal, wired in place with 14 gauge black iron wire. All joints between blocks shall be filled with asbestos cement and a 1/2" of asbestos cement shall be applied over the blocks. The asbestos cement shall be troweled to a smooth finish and insulation shall be finished with an 8 oz per sq yd canvas jacket pasted and sewed in place.

10. Piping Insulation - General Information

a. Canvas Finish

All single thickness pipe covering shall have a standard weight canvas jacket pasted on with sufficient lap to

insure a permanent fastening of the covering. All double layer coverings shall have a standard weight canvas jacket pasted to the outer layer.

All pipe covering pipe bends after the finishing coat of cement is dry shall have a canvas jacket equal to 6 oz per sq yd pasted on. This canvas must be capable of shrinking and stretching where required to form a jacket for the bend with a minimum number of cuts and shall be well pasted on throughout the entire covering surface of the bend.

All fittings, valves, flanges, etc., shall be finished with a 4 oz per sq yd canvas jacket pasted on after the final coat of cement is thoroughly dry.

b. Painting

The outside surface of all insulation not exposed to weather shall be painted with one coat of sizing and two coats of lead and oil paint of a selected color.

c. Pipe Covering Bands

All pipe covering shall be finished with pipe covering bands spaced 18" on centers.

Pipe covering bands may either be brass lacquered or black japanned tin plate, but unless otherwise directed all bands must be of the same finish.

d. Waterproofing for Outdoor Piping, Fittings, Etc.

All pipe covering where exposed to the atmosphere shall be protected with an asbestos roofing jacket weighing not less than 55 lbs per 100 sq ft.

This jacket shall be lapped at all longitudinal and transverse joints at least 4". All roofing shall be lapped so as to shed water away from the roofing joint. All laps shall be cemented with a good grade lap cement and additionally secured with coppered staples where necessary to make a tight joint.

The roofing shall be wired on with No. 13 medium soft pure copper wire in single loops on 4" centers.

All pipe bends, fittings, valves, etc., shall be weatherproofed with plastic clay type asbestos fibered fireproof emulsion applied not less than 1/4" thick. The emulsion must be troweled to a smooth finish and shall be extended onto adjacent roofing jacket at least 4".

M. Water Supply

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary to furnish, test and deliver, complete, the water supply subsystem for the Metal Parts Furnace Module as specified herein.

b. The water supply system will be constructed within the Metal Parts Furnace Enclosure by the Piping Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. Piping will be installed within a protective enclosure. Ambient conditions will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods.

d. The water supply piping subsystem shall be field tested. Testing will include a hydrostatic pressure test of not less than 150 psi for a period of two hours. All defects disclosed as a result of this test shall be remedied and defective work or materials shall be replaced and tests repeated. All repairs shall be made with new materials and no caulking of screwed joints, holes or cracks will be acceptable.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Description

The water supply system is shown schematically on the Concept Design Drawing, Sheet L-59. Water supply components are to be furnished to meet the following specifications:

a. Primary Treatment Unit

Contractor will furnish a primary treatment unit consisting of a filter and a chemical feeder to control pH and hardness.

1) The primary treatment system will be selected to have a rated capacity of 13 gpm and a design rating of 22 gpm.

2) The filter will be selected for removal of suspended matter and turbidity.

3) A chemical feeder and pH controller will be provided to reduce the alkalinity of the water and to prevent the build-up of calcium carbonate scale.

4) The pH controller shall be interlocked so as to prevent operation of the reverse osmosis unit when the pH of the water goes out of operating limits.

5) The control unit will be mounted in the cabinet provided with the reverse osmosis unit.

b. Secondary Treatment Unit

Contractor will furnish a secondary, reverse osmosis type, treatment unit for purification of water to meet boiler feedwater quality requirements.

1) The reverse osmosis unit will be selected for 6000 gpd capacity of treated water.

2) The reverse osmosis unit will be a pre-engineered, packaged unit.

3) Space for the unit will be provided within the enclosure. Space has been allocated for a unit having a height of 4'-1", a width of 3'-9" and a length of 14'-9".

4) Manufacturer will test the water samples furnished to him for that purpose, and provide anticipated performance and operating information.

5) The packaged unit shall be complete with high pressure pump, reverse osmosis membranes, temperature controller, pressure controller, pressure gauge, water quality indicator, waste water flow controller, and treated water meter.

6) Control equipment will be mounted in an integral, NEMA 4, control cabinet. The equipment will be shop wired complete.

7) The control signal for starting and stopping the system will be furnished by others from a level control unit which monitors the water level in the 3000 gallon treated water head tank.

c. Treated Water Head Tank

Contractor shall furnish a 3000 gallon capacity treated water head tank.

1) This tank shall be located in the scrubber enclosure tower.

2) The tank shall be complete with openings for level sensing elements.

3) The tank shall be fabricated of galvanized carbon steel.

d. Treated Water Pumps

Treated water pumps, pumps numbered 317 A & B will be furnished by others as part of the total pump procurements. Specifications for these pumps are set forth in Section I of these Specifications.

6. Piping Specifications

a. General

1) Water lines to have a pitch of 1" in 50'.

2) All pipes shall be cut accurately and be worked into place without springing for forcing.

3) Piping shall be installed to permit free expansion without causing damage or changing pitch.

4) All changes in directions to be made with fittings.

5) Provide and install all necessary inserts or through bolts for pipe hanger, anchors, etc.

6) All nipples shall be same material as adjoining pipe.

7) Bushings or all thread nipples will not be permitted.

8) Pipe fittings shall be thoroughly cleaned before erection to remove foreign material.

b. Installation

1) Pipe and fittings must be free from fins and burrs.

2) Screw joints shall be made with a lubricant applied on male threads only. The caulking of screw connections or wrapping of threads to make them tight is prohibited.

3) Where outlets are indicated or specified for future equipment, the lines shall be extended not less than 6" beyond main valve and capped for future connections.

c. Sleeves

1) Furnish and set all sleeves for pipes passing through enclosure walls.

2) Sleeves passing through shroud walls are to be sealed.

d. Hangers

1) Support all piping from the building structure by means of approved hangers, supports and anchors in such a manner as to maintain the required grading and pitching of lines, to prevent vibration, to secure the piping in place and to provide for expansion and contraction.

2) For steel or copper pipe, provide hangers on ten-foot centers for pipes 1 1/4" and larger and on eight-foot centers for pipes smaller than 1 1/4".

3) Unions shall be installed adjacent to all equipment and all other places wherever their presence will facilitate easy removal of equipment for renewal or repairs.

4) Unions 1 1/2" and smaller in lines of copper tubing shall be standard weight, all brass, ground joint type. Unions 1 1/2" and smaller in lines of iron or steel piping shall be standard weight of the screwed malleable pattern of the ground joint type with brass seat, suitable for 300 pounds of water pressure. Unions 2" or larger in lines of copper tubing shall be all brass standard weight flanged pattern gasket type. Unions 2" and larger in lines of iron or steel piping shall be standard weight flanged pattern gasket type. All unions shall be Crane or equal. Bolts and nuts shall be brass, galvanized or black steel to suit the unions in which they are installed.

e. Gaskets

1) All flanged unions shall be made up with 1/16" thick ring gaskets of compressed asbestos or rubber sheet, suitable for the service and equal to Granite or Durable.

f. Valves

1) Install all valves as shown on the drawings and specified herein. All valves are not shown in every instance on the drawings but, whether shown or not, all valves necessary for the proper operation of the system shall be furnished and installed by this Contractor. All valves shall be installed in accessible places.

2) All shutoff valves shall be gate valves except where throttling action is required. Throttling control valves and bypass valves shall be globe pattern.

3) All valves shall have iron hand wheels. Hand wheels for valves 2" and smaller shall be of the non-heating type.

4) All valves shall be fully packed with braided or moulded graphite impregnated asbestos packing and ready for service.

5) All valves shall be installed with stems above horizontal where possible.

6) All valves in water piping lines shall be gate valves unless otherwise indicated on the drawings or specified herein. Water valves shall be located as follows:

   a) Main shutoff valve where indicated on the drawings and within the building.

   b) Shutoff valves on each branch connection.

7) Globe and angle valves shall be all brass or bronze with renewable composition disc, screwed bonnet, or standard weight (300 pounds water) equal to Crane No. 7.

8) Gate valves shall be all brass or bronze of standard weight (200 pounds water) equal to Crane No. 422.

9) Check valves shall be all bronze or brass of standard weight (300 pounds water) with renewable composition disc, screwed bonnet, equal to Crane No. 27.

7. Water Requirements

Water requirements for the Metal Parts Furnace Module are summarized as follows:

	Average Use Rate	Maximum Rate
Shower, gpm	0.3	10
Floor wash, gpm	0.1	50
Primary treatment, gpm	13.1	22
Totals	13.5	82

N. Oil Supply

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary to furnish, test and deliver, complete, the oil supply subsystem for the Metal Parts Furnace Module as specified herein.

b. The oil supply system will be constructed within the Metal Parts Furnace Enclosure by the Piping Contractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. Pumps and filters will be installed within a protective enclosure. Ambient conditions will range from 50 F during extended winter shutdown periods up to 110 F during summer operating periods. Some piping will extend into 200 F ambient areas.

d. The oil supply piping subsystem shall be field tested. Testing will include a hydrostatic pressure test of not less than 50 psig over design pressure for a period of 2 hours. All defects disclosed as a result of this test shall be remedied and defective work or materials shall be replaced and tests repeated. All repairs shall be made with new materials and no caulking of screwed joints, holes or cracks will be acceptable.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Description

The oil supply system is shown schematically on Concept Design Drawing, Sheet L-56. The oil is pumped from the storage tank to the burners and back to the storage tank. The oil flow to the burners is regulated by the pressure in the return line. The oil supply components are to be furnished to meet the following specifications:

a. A dual pump system with each pump capable of providing 140 gph No. 2 fuel oil at 400 psig will be provided to supply burner oil.

b. There will be pressure sensors and automatic switchover to the standby pump if the oil delivery pressure drops below 300 psig.

c. Three (3) filter sets will be provided with each set having two (2) filters and cross-linked ball valves for smooth changeover. The filters shall have a disposable cartridge.

d. A single pump will provide 2 gpm of No. 2 fuel oil at 100 psig for the boiler and emergency power generator.

e. One (1) 3000 gallon and one (1) 500 gallon oil storage tank with proper ventilation shall be provided. The tanks shall have level indicators and high and low level alarms.

6. Piping Specifications

a. General

1) Oil lines to have a pitch of one inch in 50 feet.

2) All pipes shall be cut accurately and be worked into place without springing for forcing.

3) Piping shall be installed to permit free expansion without causing damage or changing pitch.

4) All changes in directions to be made with fittings.

5) Provide and install all necessary inserts or through bolts for pipe hanger, anchors, etc.

6) All nipples shall be same material as adjoining pipe.

7) Bushings or all thread nipples will not be permitted.

8) Pipe fittings shall be thoroughly cleaned before erection to remove foreign material.

b. Installation

1) Pipe and fittings must be free from fins and burrs.

2) Screw joints shall be made with a lubricant applied on male threads only. The caulking of screw connections or wrapping of threads to make them tight is prohibited.

3) Where outlets are indicated or specified for future equipment, the lines shall be extended not less than 6 inches beyond main valve and capped for future connections.

c. Sleeves

1) Furnish and set all sleeves for pipes passing through enclosure walls.

2) Sleeves passing through shroud walls are to be sealed.

d. Hangers

1) Support all piping from the building structure by means of approved hangers, supports and anchors in such a manner as to maintain the required grading and pitching of lines, to prevent vibration, to secure the piping in place and to provide for expansion and contraction.

2) For steel or copper pipe, provide hangers on 10 foot centers for pipes 1 1/4" and larger and on 8 foot centers for pipes smaller than 1 1/4".

3) Unions shall be installed adjacent to all equipment and all other places wherever their presence will facilitate easy removal of equipment for renewal or repairs.

4) Unions 1 1/2" and smaller in lines of copper tubing shall be standard weight, all brass, ground joint type. Unions 1 1/2" and smaller in lines of iron or steel piping shall be standard weight of the screwed malleable pattern of the ground joint type with brass seat, suitable for 300 pounds of water pressure. Unions 2" or larger in lines of copper tubing shall be all brass standard weight flanged pattern gasket type. Unions 2" and larger in lines of iron or steel piping shall be standard weight flanged pattern gasket type. All unions shall be Crane or equal. Bolts and nuts shall be brass, galvanized or black steel to suit the unions in which they are installed.

e. Gaskets

1) All flanged unions shall be made up with 1/16" thick ring gaskets of compressed asbestos or rubber sheet, suitable for the service and equal to Cranite or Durable.

O. ENCLOSURE

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to design, furnish and erect, complete, the enclosure as specified herein.

b. The enclosure shall be erected by the Enclosure Contractor. Installation shall be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The enclosure will be installed on poured concrete foundations, reference Section P of this specification. Ambient conditions will range from -10°F during winter months to 110°F during summer months.

d. The enclosure shall be assembled on the site using bolted joints and/or welded joints, and gaskets and be transportable by railroad flat car. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. The enclosure parts shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be designed and built in accordance with the best engineering and manufacturing practices.

4. Approval of Material and Equipment

The enclosure Contractor shall submit certified construction design drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the prime Contractor.

5. Description

a. Architectural and dimensional features of the enclosure are shown on the Concept Design Drawings. The applicable drawings are:

Sheet	L-32	Architectural Elevations
Sheet	L-34	Scrubber Tower
Sheet	L-39	Shroud Arrangement I
Sheet	L-40	Shroud Arrangement II
Sheet	L-52	Architectural Roof Plan
Sheet	L-73	Architectural Floor Plan

b. Furnace Enclosure

The furnace enclosure shall house the metal parts furnace, the multi-position loader, the charge and discharge cars and other related equipment. This enclosure shall be a standard 40'-0 wide rigid frame, 20'-0 high at the eaves, pre-fabricated building. The nominal length of this enclosure shall be 100'-0.

c. Scrubber Tower and Corner Enclosure

The scrubber tower 20'-0 x 20'-0 in plan x 50'-0 high is contained within the corner enclosure. The scrubber tower shall house the gas scrubbing equipment, stack and related equipment. The corner enclosure other than containing the scrubber tower shall house bulk item and projectile unloading equipment, cooling stations, boiler, discharge car control room and E.G.M.S. The corner enclosure is of irregular "L" shape whose outside dimensions are 75'-0 x 60'-0 and is 16'-0 high.

d. Brine Treatment Enclosure

This enclosure shall house the brine treatment equipment and retention tanks. This portion of the enclosure shall be 50'-0 wide x 80'-0 long and 20'-0 high at the eave, of pre-fabricated rigid frame construction. This enclosure shall

have a 10'-0 wide x 18'-0 long leanto, located at the north-east corner to cover the salt drum loading dock.

e. Shrouds

Interior isolation shrouds shall be provided to isolate the multi-position loader, the metal parts furnace and the fume burners from the scrubber and brine treatment enclosures. The multi-position loader shroud will be 20'-0 wide x 23'-0 long with a 16'-0 high ceiling. The charge car shroud will be 14'-0 long x 30'-0 wide with a 16'-0 high ceiling. The furnace shroud shall be 47'-0 long x 25'-0 wide with a 20'-0 high ceiling and is subject to operating ambient temperatures of 50°F to 200°F.

f. Airlock Shower

A shower stall shall be provided. This shower will be a nominal 4'-0 wide x 6'-0 long with an 8'-0 ceiling height. Personnel doors will be provided at each end of the shower stall for accomplishing the airlock function.

g. Brine Processing MCC Room

A motor control center room shall be provided for housing electrical motor controls and located in the southeast corner of the brine treatment enclosure. This room shall be 12'-0 wide x 10'-0 long with a 10'-0 ceiling height.

h. Brine Processing Operator Room

An operator room shall be provided, adjacent to the brine processing MCC room.
This room shall be 8'-0 wide x 10'-0 long with a 10'-0 ceiling height.

i. MPL Control Room, E.G.M.S., Discharge Car Control Room

These rooms shall be made of sandwiched steel panel roof side walls and erected on a floor system which will make them suitable as portable buildings. The sizes and locations of these enclosures are given on Drawing L-73, Architectural Floor Plan. These rooms shall have an 8'-0 ceiling as measured from the top of the skid onto which they are built. The top of skid shall act as floor and shall be no higher than 8" above the enclosure slab.

6. Design Criteria

a. Roof design live loads shall be 30 p.s.f. snow load applied to the horizontal roof projections and design wind pressures shall be 20 p.s.f. applied to the primary framing and wall components. An additional roof vertical load of 10 p.s.f. shall be applied to the primary framing to simulate pipe, conduit and other hanging loads.

b. The scrubber tower has intermediate level platforms, stair platforms and stairs which shall be designed for a live load of 100 p.s.f. Moreover, a wind load of 20 p.s.f. on the tower with an additional load of 30 p.s.f. on the cylindrical stack shall be provided.

c. The shroud enclosure shall be designed for a ceiling live load of 30 p.s.f. unless otherwise required. Concentrated loads such as pipe hangers are additional. To the above a side load of 10 p.s.f. acting inward or outward on the side walls shall be provided.

d. Miscellaneous Loads

Loads resulting from support of equipment such as tanks, cranes and other superimposed loads other than pipe and conduit loads shall be given cognizance in the equipment specifications to which equipment they pertain. (It should be stated that the equipment loads are unknown during the concept design stage, therefore they will be given to the Contractor when available to form the basis for his design of structures.)

e. Gabled Roof

Prefabricated type buildings of 40'-0 and 50'-0 widths shall be designed only for loads as given in paragraph (a) and shall not be subject to equipment loads as specified in paragraph (d).

7. Structural Design Specifications

a. Prefabricated Buildings

1) The main framing shall be designed in accordance with the latest edition of AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings."

2) Purlins, girts and all other cold-formed steel structural members, shall be designed in accordance with the latest edition of AISI "Specification for the Design of Cold-Formed Steel Structural Members."

b. Custom Designed and Fabricated Buildings

Custom designed and fabricated buildings such as scrubber tower and corner enclosure shall be designed in accordance with the latest edition of AISC "Specification for the Design, Fabrication and Erection of Steel for Buildings."

c. Shrouds

Shrouds shall be designed in accordance with the latest edition of AISC "Specification for the Design, Fabrication and Erection of Steel for Buildings."

d. Pre-fabricated Rooms

Pre-fabricated rooms made up with all cold-formed steel structural members shall be designed in accordance with the latest edition of AISI "Specification for the Design of Cold-Formed Steel Structural Members."

8. Architectural Specifications

a. Pre-fabricated Buildings

Pre-fabricated buildings shall have features that are standard with the best industry practices and shall meet with the following minimum requirements:

1) Pre-fabricated buildings shall have 4" to 12" roof slope of symmetrical gable roof construction.

2) Pre-fabricated buildings shall be clad with sandwich metal insulated siding panels and metal roof with 4" bat insulation applied on the bottom of the roof panels. Roof panels shall be 24-gauge galvanized and painted, cold formed of 42,000 yield point steel sheet. Likewise, siding panel sandwiches shall be formed with same sheet, comprised of 24-gauge thickness of outer sheet, 3/4" thick of 6 lb. density insulation, covered with inner sheet of 26-gauge thickness. Building panels shall be shop coated with a minimum of two coats of manufacturer's standard green applied over one coat of primer or manufacturer's standard paint specification if it exceeds the

minimum requirements stipulated above.

3) Doors

a) Personnel doors shall meet the requirements of Commercial Standards PS-4-66 and CS242-62 as issued by the U.S. Department of Commerce.

b) Doors and door frames shall be constructed of galvanized steel of suitable gauge thickness and prime painted.

c) Doors and door frames shall be installed in accordance with the manufacturer's instructions.

d) Roll-up steel curtain door shall be of steel slat design, 20-gauge galvanized, complete with chain operators.

4) Windows

a) Windows shall be aluminum horizontal slide type.

b) Windows shall meet the requirements of an Architectural Aluminum Manufacturer's Association Specification HS-A2.

c) Windows shall be completely assembled, glazed and with screens.

5) Ventilators

a) Ventilators shall be fabricated from galvanized steel and equal ASTM Specification A525, G90 Coating.

b) Ventilators shall be Low Profile 20" diameter galvanized steel, ridge type, gravity operated, with bird screen and necessary closures. Counter-weighted damper shall be furnished with 6' operating chain.

c) All 20" diameter ventilators shall have collar and closures for installation on roof ridge.

d) Based on 10° temperature difference and 20'-0 stack height, approximate exhaust capacities in cubic feet per minute shall equal or exceed 635 CFM for a 5 miles per hour air movement, and 1150 CFM for 10 miles per hour movement.

b. Custom Designed and Fabricated Buildings

Custom designed and fabricated buildings shall have architectural features as those of paragraph 8-a, except for the following:

1) Method of fastening of the siding to structural channel girts and roofing to structural purlins.

2) The roof of this enclosure, including tower roof shall have a minimum slope of 1/2" to 12" and shall be 1-1/2" 24-gauge or heavier metal deck construction with rigid insulation, minimum thickness 1", vapor barrier (as approved by Factory Mutual and/or F.I.A.) and a 20-year built-up composition roof topped with gravel.

3) Purlins, girts and main framing shall consist of standard structural slopes.

4) Painting Specifications

One coat of shop paint and one coat of field paint.

c. Shrouds

Enclosures within the building enclosures necessary for ventilation and/or safety requirements are hereby referred to as "shrouds." These shrouds are air-tight structures able to withstand pressure differentials of 10 p.s.f. and able to withstand the ambient conditions within the enclosure. The construction of the shrouds shall be substantially as shown on the drawings and shall consist of the following:

1) Main steel framing at 8'-0± o.c. consisting of two columns and roof beam.

2) The panels of this structure shall be stiffened with structural angles and channels and shall consist of 1/8" steel plate attached to the main frames by means of bolts and rubber gaskets.

3) Observation windows shall consist of hollow metal window frames glazed with Thermo-Setting Unbreakable Transparent Panels, Type CR-39.

4) Roof construction of shrouds shall be similar to side wall construction covered in paragraph 2).

5) Doors and door frames shall be of same construction as covered under paragraph a.3).

d. Prefabricated Rooms

All pre-fabricated rooms shall be of dimensions as called for in these specifications and accompanying drawings built with gauge metal sandwich insulated panels, complete with wiring, heating and air conditioning and all features necessary to render them complete indoor house units for the purposes intended as implied by their names on the drawings. The supplier of these pre-fabricated rooms shall submit samples of his work and standard designs of doors, windows, ceiling panels, floor panels, etc. along with his proposal to do this work. The pre-fabricated houses shall further conform to the following minimum requirements:

1) The outer set of sandwich panels shall be not less than 16-gauge steel which will be backed up by insulation and inside panel of no less than 20-gauge thick.

2) Roof panels shall be same as side wall panels.

3) Floor shall consist of light weight steel framing forming the grid of a skid onto which the room is assembled in the shop and having a covering able to withstand a floor live load of 200 p.s.f. (except for MCC rooms which rooms will require structural steel channel load spreaders at MCC cubicles)finished with vinyl floor tile and easy-to-clean cove base.

4) Electrical requirements for these rooms are covered under another section.

5) Heating and air conditioning requirements for these rooms are covered under separate heading.

P. FOUNDATIONS

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to design and install, complete, the foundations and floor slab as specified herein.

b. The foundations shall be installed by the Foundation Contractor. Installation shall be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The foundations will be installed on previously prepared site, reference Section R of this specification. Ambient conditions will range from -10°F during winter months to 110°F during summer months.

d. Underlying soil foundation conditions are described in detail in "Soils Report" which is available to the Contractor for his guidance.

e. All foundation work consisting of, but not limited to, concrete, anchor bolts and buried steel items, shall be monitored for accuracy, workmanship and materials making up the work. The testing of concrete, sub-grade, compaction and all other materials pertaining to the work shall be conducted as described under the heading of "Field Testing" under the ASTM specifications for each subject material.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. The foundations and floor slab shall be constructed as per the dimensions and sizes shown on the drawings which are to be prepared by Contractor and placed in accordance with the instructions, specifications and field inspection personnel under the direction of the Contracting Officer. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All foundations shall be designed and built in accordance with the best engineering practices, national and local applicable codes.

4. Approval of Material and Equipment

The foundation Contractor shall submit certified construction design drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to installation.

Written approval will be provided by the designated representative of the prime Contractor.

5. Description

a. Foundation and drains outlines pertaining to this project are shown on concept design drawing Sheet L-36. The following reference drawings which are mainly architectural are pertinent to the foundation and floor slab work and are made part of this specification:

Sheet L-34 Scrubber Tower
Sheet L-39 Shroud Arrangement I
Sheet L-73 Architectural Floor Plan

b. Foundations for Furnace Enclosure

The foundations for furnace enclosure consist of spread footings and column piers supporting enclosure main columns. This area shall have floor slabs to support floor loads of intensities up to 250 p.s.f. Foundations for the MPF, the MPL, the charge and discharge cars and other related equipment under this enclosure will mainly consist of thickened portions of the floor slab. For special foundation conditions under above equipment, see separate paragraph.

c. Foundations for Scrubber Tower and Corner Enclosure

The foundations for scrubber tower and corner enclosure consist of spread footings and column piers supporting enclosure main columns. This area shall have floor slabs to support floor loads of intensities up to 500 p.s.f. Foundations for scrubber equipment are described in separate paragraph.

d. Foundations for Brine Treatment Enclosure

The foundations for the brine treatment equipment and retention tanks shall be dealt with in a separate paragraph. The foundations consisting of piers and spread footings for the main enclosure columns, grade beams, floor slabs, curbs, pits, etc. constitute this work.

e. There shall be no special foundations for shrouds and interior pre-fabricated rooms because they are treated as portable items and therefore necessitate a floor slab to sustain their loads. This floor slab shall be designed for 250 p.s.f.

f. Equipment Foundations

Equipment foundations shall be designed and installed to sustain the loads superimposed to them by the equipment involved. (It should be stated that the equipment loads are unknown during the concept design stage, therefore, they will be given to the Contractor when available to form the basis for his design of structures.) Tanks, drains, sumps and in some cases equipment that extends below the floor line will require pits and covers for same. This work when known will be a part of the foundation contract.

6. Design Criteria

a. As determined from the "Soils Report" the soil on which these foundations will be constructed can sustain a gross bearing of 2,000 p.s.f. with tolerable settlements.

b. The superimposed live and dead loads on the foundations plus the dead load of piers, footings and floor slab shall be computed, and footings sized accordingly for distribution of loads to the foundation soil.

c. Concrete, reinforcing steel, steel wire mesh, expansion joint material and all other materials that constitute the installation of a completed piece of foundation work shall be proportioned according to the ACI Code and the best practices of the art in matters of waterproofing, installing curbs, expansion joints and all other work incidental to the foundations and floor slabs.

7. Foundation Materials

a. Cement - Specification for Portland cement ASTM C-150.
Reinforcing Bars - Deformed bars of billet steel, ASTM A615.
Premolded Joint Filler - Bituminous fiber, non-extruding, 1/2" thick and widths to suit locations.
Liquid Floor Hardener - Commercially available "Concrete Floor Treatment."
Aggregates - Specifications for Concrete aggregates,ASTM C-33.

b. Concrete Mixes and Testing

All concrete shall be ready mixed, of controlled stone, gravel or slab to test 3,000 p.s.i. in standard 6" x 12" cylinders at 28 days, using not less than 5-1/2 packs of cement per cubic yard of concrete, regardless of strength obtained; not over 6-1/2 gallons of water per sack of cement and not over 4-inch slump.

c. Form Work

Neatly constructed of finished plywood. Forms and centers shall be clean, watertight, substantial and sufficiently tied and braced to maintain proper positions and dimensions during placing, spading and vibrating of concrete. Do not strike or remove forms until concrete has developed sufficient strength to safely support imposed loads.

d. Placing Concrete

1) Before placing concrete, remove from reinforcing steel excessive rust or other coatings that would reduce or destroy bond. Thoroughly clean forms of wood chips, shavings, or other debris. Do not deposit concrete in standing water.

2) Thoroughly work concrete around reinforcement, embedded items, and into the corners of forms, without displacing reinforcement. Perform concreting at such rate that concrete is at all times plastic and flows readily into spaces between reinforcement members.

3) Use approved type of internal vibrator in all concrete. Do not leave in same position longer than 5 seconds.

e. Anchors, Sleeves, Inserts, Etc.

Embed into concrete work all anchor bolts for equipment. Projection of bolts beyond concrete surfaces shall be adequate for intended correct attachment. Protect bolt threads against rust with oil and waterproof caps.

f. Joints in Slabs

Make expansion joints where necessary around building column piers, grade walls, pits, etc.

g. Finishing Concrete

1) All concrete floor areas shall be finished monolithically, striking off rough concrete to true level screeds, floated, and steel trowelled to a smooth, hard, uniform surface.

2) After concrete has set sufficiently to be walked upon, treat with liquid hardener.

h. Curing

All concrete floor areas shall be kept from too rapid drying by means of an approved curing-hardening-sealing compound.

j. Protecting

Adequately protect concrete from mechanical or other damage for at least seven days after pouring. In cold weather, provide enclosures and supplementary heat as recommended by the ACI. The use of unvented space heaters will not be permitted.

k. Defective Concrete

If any concrete is found defective in strength, not true to line or level, or poured out of position, the Contracting Officer may direct that such concrete be removed and replaced, or that other corrective measures be taken as he determines, at no extra cost to the Government.

R. Site Preparation

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to prepare the site for foundations of enclosures, drives and surface drainage as specified herein.

b. The site to be prepared is adjacent to an existing installation on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. Ambient conditions will range from -10°F during winter months to 110°F during summer months.

d. The soil conditions at the site are described in detail in "Soils Report" which is available to this Contractor for his guidance.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

The excavation, embankment and grading operations shall be carried out as per the dimensions and sizes shown on the drawings which are to be prepared by this Contractor and placed in accordance with the instructions, specifications and field inspection personnel under the direction of the Contracting Officer. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All site work shall be carried out in accordance with the best engineering practices.

4. Approval of Materials and Equipment

The Contractor shall use materials and equipment to perform his grading and other site preparation operations so as not to disturb any of the existing Government property adjacent to the site on which he is to work. Any interruption of services that are necessary for his operations shall be authorized by written approval from the Contracting Officer. Materials used for embankment shall be approved in advance, after laboratory

tests of same.

5. Description

The site preparation Contractor shall do all work required within the work limits of this Contract which are delineated on the site plan, Drawing L-35 and furnish all necessary materials and labor to install the following work:

a. Clearing site of all above and below grade obstructions.

b. Removal of existing pavements in area of new addition.

c. Excavating for all enclosure foundations.

d. Pumping and disposal of water from excavations.

e. Shoring, bracing, furnishing of barricades.

f. Backfilling and compating.

g. Removal and disposal of unsuitable excavation materials.

h. Rough and finish grading of building area.

j. Rough and finish grading of site.

6. Materials and Workmanship Specification

a. Excavation

1) Do all excavation necessary for the wall footings, piers, drains, etc., as indicated on the drawings.

2) If soil conditions permit, footing and equipment foundation excavations in soil, may be of exact size. If soil is too unstable to permit forming in earth banks, then excavation shall be sufficient size to permit construction and removal of forms.

3) All excavations shall be cleaned, leveled and trimmed as required for the installation of concrete; and in general this work shall be done just before concrete is placed. Bottoms shall be free from debris and water when concrete is placed.

4) All excavations shall be properly protected from freezing.

5) If explosives must be used, then the Contractor shall observe the following:

a) Follow all of the requirements of the latest issue of Volume III, "Construction Standards and Interpretations"of O.S.H.A. by the U.S. Department of Labor, subpart U, titled "Blasting and Use of Explosives."

b) Where explosives are used, work shall be done by experienced power men using small charges and in strict accordance with all regulations governing this work. Any damages, on or off site, caused by improper use of explosives shall become the complete responsibility of this Contractor.

c) Provide all necessary barricades, etc., as required by law or others to safeguard life and property, both on and off site.

b. Pumping

Keep excavations free from water at all times and provide and operate pumps or other approved method as required. Operate pumps night and day, if necessary. Do not allow water to wash freshly laid concrete or masonry.

c. Embankment and Backfilling

1) Do all required backfilling of excavations for concrete work.

2) Backfilling of excavations outside of building shall be with suitable approved material.

3) Backfill materials inside the building shall be placed in layers not over 6" thick, loose measurements and thoroughly compacted to 90% optimum by machine tamping to prevent settlement. Backfilling against free standing walls shall be made against both sides at the same time. If backfill is required on one (1) side only, the wall shall be properly braced on the other side.

4) Provide and compact #4 size crushed stone or washed gravel drainage fill under all concrete floor slabs on ground. Drainage fill shall be four inches deep under slabs after compaction.

5) Compact all sub-grades by mechanical means to achieve compaction percentages stipulated below, as measured by the modified AASHO method.

   a) Areas under enclosures - 95% Mod. AASHO

   b) Areas under pavement - 95% Mod. AASHO

   c) Shoulders and apron - 90% Mod. AASHO

d. Disposal of Materials

All debris, rubbish and refuse material resulting from the excavation and grading operations shall be removed and spoiled by this Contractor, as directed by the Contracting Officer.

S. Heating

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to furnish, test and deliver, complete, the heating subsystem for the Metal Parts Furnace Module as specified herein.

b. Heating subassemblies shall be erected by the Steam Supply Subcontractor. Installation will be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The heating subassemblies shall be transportable by railroad flat car. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

d. The steam heater units shall be shop tested prior to shipment to the installation site. Testing will consist principally of pressure testing the coils.

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. Piping and external equipment shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be built in accordance with the best engineering practices.

4. Approval of Material and Equipment

The Subcontractor/Supplier shall submit certified construction drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the Prime Contractor.

5. Description

The heating system is shown schematically on the Concept Design Drawing, Sheet L-58 and L-72. Components are further described as follows:

a. General Heating Coils

The Contractor will furnish heating coils of the plate fin extended surface type for heating the Scrubber Enclosure, the EGMS and the MCC. The heating coils will meet the following specifications:

1) Coils to be finned tube radiation type, suitable for steam service. The radiators will be mounted on the interior walls of the Scrubber Enclosure.

2) The heating system will be designed to maintain a temperature of 50 F in the scrubber enclosure with an outside temperature of -10 F and a wind velocity of 10 mph.

b. Local Heating Coils

The Contractor will furnish heating coils of the plate fin extended surface type for local heating of the MPF shroud. The heating coils will meet the following specifications:

1) Coils to be finned tube type, suitable for steam service. The radiators will be mounted on interior walls of the MPF shroud.

2) The heaters shall be capable of delivering 50,000 Btu/hr per unit; two units are required. Air movement will be by natural convection only.

T. Ventilation

1. Scope of Work

a. This section of the specifications covers the furnishing of all labor, materials, tools, equipment and performing all work and services necessary or incidental to design, furnish and erect, complete, the ventilation system as specified herein.

b. The ventilation duct work shall be erected by the Ventilation Contractor. Installation shall be on Government property located in the South Area of the Tooele Army Depot in Tooele, Utah.

c. The ventilation duct work shall be assembled on the site using bolted joints and/or welded joints, and gaskets and be transportable by railroad flat car. Subassemblies, when disassembled for transport, shall be limited to the following:

Length	40 feet
Width	10 feet
Height	11 feet
Gross Weight	40 tons

2. Guarantee

All work under this section of the specifications shall be guaranteed for one year from the date of its acceptance by the Contracting Officer.

3. Workmanship

Labor shall be performed by skilled mechanics and craftsmen experienced in their particular trade. The ventilation parts shall be installed square and plumb, with accessibility for proper operation and service. Any component or part thereof which does not present a neat and workmanlike appearance shall be replaced or corrected at the direction of the Contracting Officer and without additional cost to the Government. All equipment shall be designed and built in accordance with the best engineering and manufacturing practices.

4. Approval of Material and Equipment

The Ventilation Contractor shall submit certified construction design drawings, shop drawings, data sheets or other descriptive material on his equipment and accessories, prior to fabrication. Written approval will be provided by the designated representative of the Prime Contractor.

5. Components

a. MPF Furnace Shroud Inlet

The system shall be capable of admitting 10,500 scfm into the shrouded area with a maximum of 0.05" w.c. pressure differential. The ambient conditions will be a maximum temperature of 110 F and minimum temperature of - 10 F at a 12.0 psia atmospheric pressure. There will be three inlet ducts feeding a distributor plenum located along the floor of the shrouded area as shown in drawing sheet L-72-D. The inlet ducts shall rise vertically to provide a 10' clearance and then extend horizontally through a building wall located 7' from the outside of the shrouded wall. The air inlet ports will contain grill covers and rain shields. The distributor plenum shall contain grill covers. Two of the ducts will be equipped with dampers located in the vertical run. The dampers will be manually operated and have a locking device to position the damper anywhere between fully open and fully closed.

b. Loading Zone Inlet

This system supplies air from the furnace shroud to the loading zone shroud. The normal flow will be 3500 acfm at 12.0 psia and temperature ranging between 50 and 200 F. During winter maintenance periods the inlet air temperature can decrease to -10 F. During these periods, a steam heater located in the duct work will automatically control the air outlet temperature at 55 $\pm$5 F. The duct will also contain a backdraft damper to prevent reverse flow, and a control damper to maintain the loading shroud at a negative pressure of 0.15" w.c. to 0.20" w.c. Both the duct inlet and outlet will be equipped with grill covers. The total pressure drop across the ducting, heater, dampers, and grills shall be 0.10 to 0.15" w.c.

c. MPL Shroud Inlet

This system shall be capable of admitting 4500 scfm of air into the MPL shroud area. The inlet air will vary from 110 F in the summer to -10 F in the winter at 12.0 psia atmospheric pressure. The inlet duct shall rise vertically to provide a minimum clearance of 12' and then extend horizontally 7' to the outside wall. The air inlet ports will have grill covers and rain shields. The air distribution plenum located inside the MPL shroud shall also have grill covers. When the inlet air temperature is less than 50 F, a steam heater located in the duct will automatically control the air temperature at 55 F ±5 F. There shall be a pressure control damper to control the flow while maintaining a constant 0.15" w.c. pressure differential.

d. Loading Zone Ventilation Duct

This duct shall extend from the loading zone to the charcoal filter, a distance of approximately feet. The duct shall have a grill covering the entry and a flange at the discharge. The air flow will be controlled (by others) at 4000 acfm measured at 12.0 psia and a temperature ranging from 50 F to 200 F. The maximum pressure loss in the duct shall be 0.85" w.c.

e. Air Lock Ventilation

The air lock ventilators shall be designed to allow 550 scfm air flow through the air lock with a pressure differential of 0.15" w.c. The inlet air will vary from 110 F in the summer to -10 F in the winter at 120 psia atmospheric pressure. The air flow will be controlled by two manually adjustable grill covers.

f. Shower Room Ventilation

The shower room ventilators shall be designed to allow 25 scfm air flow through the room with a pressure differential of 0.15" w.c. The inlet air will vary from 110 F in the summer to -10 F in the winter at 12.0 psia atmospheric pressure. The air flow will be controlled by two manually adjustable grill covers.

g. General Information

All ducting shall be fabricated from galvanized sheet metal. All grill covers shall be painted to avoid rusting.

Duct sizes shall be based upon 900 to 1000 FPM; grill sizes shall be based upon 400 FPM velocities.

Steam piping and insulation will be field installed by the Steam Supply Subcontractor(s).

The Government shall supply the absolute chemical filter system and ventilation fans.

APPENDIX A

HERCULES INCORPORATED
ALLEGANY BALLISTICS LABORATORY
CUMBERLAND, MARYLAND

HUMAN FACTORS ENGINEERING ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

M. J. KATZ

NOVEMBER 11, 1974

PREPARED FOR

MIDLAND ROSS CORPORATION
SURFACE COMBUSTION DIVISION

PRIME CONTRACT DAAA-15-74-C-0092
PURCHASE ORDER D66741-0
JOB NUMBER PC-1259-1

HERC NO. 74-80

REPORT NO. A08207-520-03-010

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HUMAN FACTORS ENGINEERING ANALYSIS
OF A METAL PARTS FURNANCE AND
AIR POLLUTION CONTROL SYSTEM

- DIGEST -

Objective

The technical objective of this program is the design of a Metal Parts Furnace (MPF), a subsystem of a Chemical Agents/Munitions Disposal System. In accordance with government regulations, a human factor engineering (HFE) analysis has been performed on the final concept design. The objectives of this analysis were to interrelate hazardous situations identified from a completed failure mode and hazardous effects analysis (FM&HEA) to the human causitive factors involved and to recommend ways of reducing their probability of occurrence.

Results and Conclusions

For purposes of the FM&HEA and the HFE analyses, the Metal Parts Furnace and Air Pollution Control System were divided into the following four subsystems: (1) the loading system, (2) the furnace system, (3) the scrubbing and salt recovery system, and (4) the unloading system. Numerous specific events (toxic leaks, explosions, equipment failure, and operator error) which could pose a hazard to personnel, equipment or the environment were identified and documented for each of these four subsystems.

This Human Factors Engineering Final Report is a record of HFE decisions and trade-offs influencing system design and it includes (1) a system description, (2) an outline of the activities performed and results achieved, (3) recommended design and operating criteria from a HFE review, and (4) a description of remaining HFE problems with recommended remedial review.

References will be made throughout this report to suggested system changes or operational limits that should serve as a useful guide in optimizing the system from the standpoint of safety, cost and reliability. Recommendations which are included in this report are summarized below:

(1) Provide for one-button control to release projectiles and to reposition tray at the monorail conveyor-multi-position loader interface.

(2) Interlock the repositioning of the tray to the release of a projectile and to a sensing device that indicates the projectile is properly positioned on the tray.

(3) Provide automatic projectile loading for the remainder of a tray row once the first position has been filled by operator action.

(4) Clear the volatilization chamber prior to proceeding with the punching operation.

(5) Require visual TV surveillance of the punching operation and operator action to initiate it.

(6) Require that a visual observance of a fire resulting from the punching operation necessitates that the bulk item be immediately sent to the volatilization chamber.

(7) Take precautions to reduce the probability of operating or maintenance personnel defeating critical interlock systems, such as the bulk item punching interlock sequence, as a consequence of an interlock component failure.

(8) Establish procedures to ensure that critical interlocks are checked periodically.

(9) Keep a production log to verify and ensure that the scrap material leaving the metal part furnace has been heated for the appropriate time at the required metal soak temperature.

(10) Do not allow brine contents from retention tank to be pumped to salt dryer feed tank until the sampling operation and certification has been acknowledged by the operator and/or supervisor on a production log.

Recommended Future Work

1. A more comprehensive safety and reliability analysis is recommended for the multi-position loader and government monorail conveyor interface since detailed operating procedures and control interlocks will not be adequately defined at the completion of the final concept design phase.

2. A thorough hazard analysis of the final detailed engineering and installation design is recommended.

3. A fault tree and reliability analysis is recommended for the automated control and emergency safety systems.

- INTRODUCTION -

This is the Human Factors Engineering (HFE) report for the Hazards and Risk Analysis of a Metal Parts Furnace (MPF), a subsystem of the Chemical Agent/Munitions Disposal System (CAMDS) under prime contract DAAA51-74-C-0092, PO Number 066741-0 and Job Number PC-1259-1.

In accordance with government regulations, a preliminary hazards analysis (PHA) had been performed on the initial concept design[1] and a failure mode and hazardous effects analysis (FM&HEA) has been completed on the final concept design.[2] The objective of these safety analyses were to identify and report specific events (toxic leaks, explosions, equipment failure and operator error) which could pose a hazard to personnel, equipment or environment. This HFE analysis for the final concept design interrelates the hazards identified in the PHA and FM&HEA to the human causative factors.

The Human Factors Engineering Final Report is a record of HFE decisions and trade-offs influencing system design. It serves as the baseline for application to subsequent system improvements, and identifies remaining HFE problems with recommendations for remedial action. This HFE Final Report on the MPF system final concept design, as specified in DI-H-1315, includes the following information:

(1) a description of the system with an outline of the activities performed and results achieved,

(2) recommended design and operating criteria based on a human factors engineering review,

(3) a description of remaining HFE problems with recommended remedial action.

- DISCUSSION OF RESULTS -

In any system, regardless of the degree of sophistication of the instrumentation and automatic control, there is a human interface which must be taken into account in system design. Generally, it is at this interface that some of the most severe hazards of a system can be found. These hazards range from a simple operator error in a familiar procedure, to a mistake resulting from insufficient training, to a "temporary system modification" so that production can be maintained when a failure has occurred preventing operation by accepted procedures. Sometimes, periodic tasks can be simply overlooked if they have no direct impact on production. The reason why they are overlooked may be that the operator did not feel that the task needed done or may be that he was too preoccupied with other concerns to attend to it on his shift.

The goal of human factor considerations as applied to a hazards analysis is thus to apply current knowledge concerning human characteristics to the task of preventing hazardous situations from arising. It is now known, for instance, that human failure rates for various types of activity are quite consistent statistically regardless of temperment or degree of training. These failure rates range from 10^{-1} per operation under circumstances requiring several non-routine decisions per minute[3] to 10^{-3} per operation for an operator following an established procedure[4] to 10^{-4} for an individual dropping an object.[5] The 10^{-3} figure represents composite data from Hercules, ABL and another large chemical plant's records, while the other two figures are derived from recent experimental studies.

The intent of this report is not necessarily to identify additional problem areas to those already pointed out in the PHA and FM&HEA analyses.[1,2] Rather, the purpose here is to emphasize the human causative factors involved in those previously identified problem areas and to recommend ways of reducing probabilities in those cases where it is qualitatively felt that the hazard probabilities may still be high.

The approach generally used in the MPF system design has been to provide electronic or mechanical redundancies (interlocks) wherever a potentially hazardous situation arising from a human error has been identified. The effectiveness of this approach can be demonstrated as follows. A typical electronic component failure rate is 1×10^{-6} per hour.[6] Assuming that this component provides a check on an operator following a procedure requiring one operation per hour, the probability of failure of the human electronic combination is:

$$(1 \times 10^{-6})(10^{-3}) = 1 \times 10^{-9} \text{ per hour}$$

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CONCEPT DESIGN REPORT. METAL PARTS FURNACE. (U)
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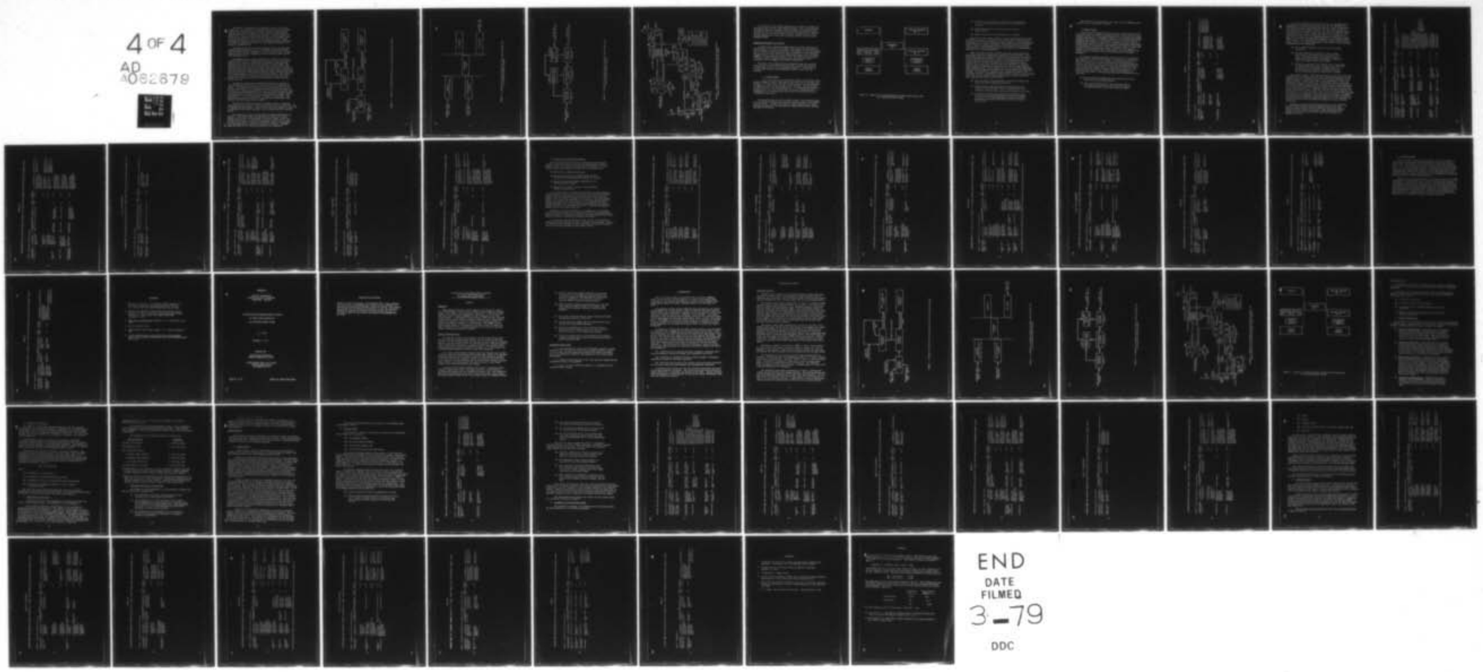

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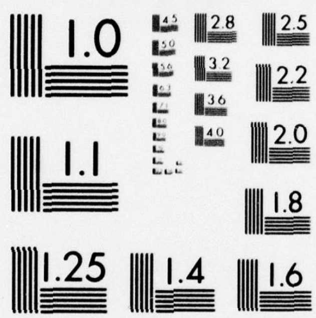

MICROCOPY RESOLUTION TEST CHART
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The failure probability of the operator alone is, of course, simply 10^{-3}. As an example, the probability of an operator causing a projectile spill at the multi-position loader by inadvertently releasing the projectile before a tray is in the proper position would be 10^{-3} if no interlocks were available. By interlocking the system with a switch to ensure that the tray is in the proper position, the probability of this incident is reduced to 10^{-9}. This technique of employing electronic or mechanical component interlocks as a check on operator activities has been followed throughout the design of the MPF system.

The Metal Parts Furnace and Air Pollution Control System shown schematically in Figure 1 can be for purposes of analysis divided into the following four subsystems: (1) the loading system, (2) the furnace system, (3) the scrubbing and salt recovery system, and (4) the unloading system.

The loading system, shown schematically in Figure 2, contains a basket loading station, a multi-position loader, an air-lock, and a transfer car. Trays are loaded with projectiles on the Government monorail system from the Pull Drain and Rinse Facility (PDR). This same monorail system is used to fill baskets at the basket loading station with burster wells from the PDR. The transfer car is designed to accept baskets of burster wells from the basket loading station and trays of projectiles from the multi-position loader and place them into the punching chamber of the metal parts furnace (MPF). The transfer car is also designed to accept trays loaded with a bulk item (ton container or spray tank) from the air-lock over the bulk item tray return conveyor.

The furnace system shown schematically in Figure 3 contains a three chamber metal parts furnace and two burners to decompose toxic vapors. The punching chamber is used as an enclosure where ton containers are punched or as a holding vestibule for other end items to be processed. Mustard is vaporized in the volatilization chamber which is maintained from 400-600°F and at a reduced oxygen atmosphere (4-6%). The vapors which are drawn into the primary fume burner (PFB), being controlled at a constant temperature of 1600°F are decomposed. The decomposition gases are then sent to the auxiliary fume burner (AFB) which is also being controlled at 1600°F.

The burn-out chamber is operated at 1000°F in order to decontaminate the metal parts and to ensure all mustard sludge is burned out. Air is supplied to this chamber. Gases from the burn-out chamber are drawn into the AFB and from there exhausted to the scrubbing and salt recovery system.

The scrubbing and salt recovery system is shown schematically in Figure 4. The furnace gases are quenched and passed to a venturi scrubber for removal of particulates. The dirty liquor is sent to a packed scrubber tower. A portion of the brine is drawn off to a salt recovery system where the salt is recovered by means of evaporation. The remaining brine is recycled to the venturi scrubber. Scrubbed gases are drawn up the stack and released to the atmosphere.

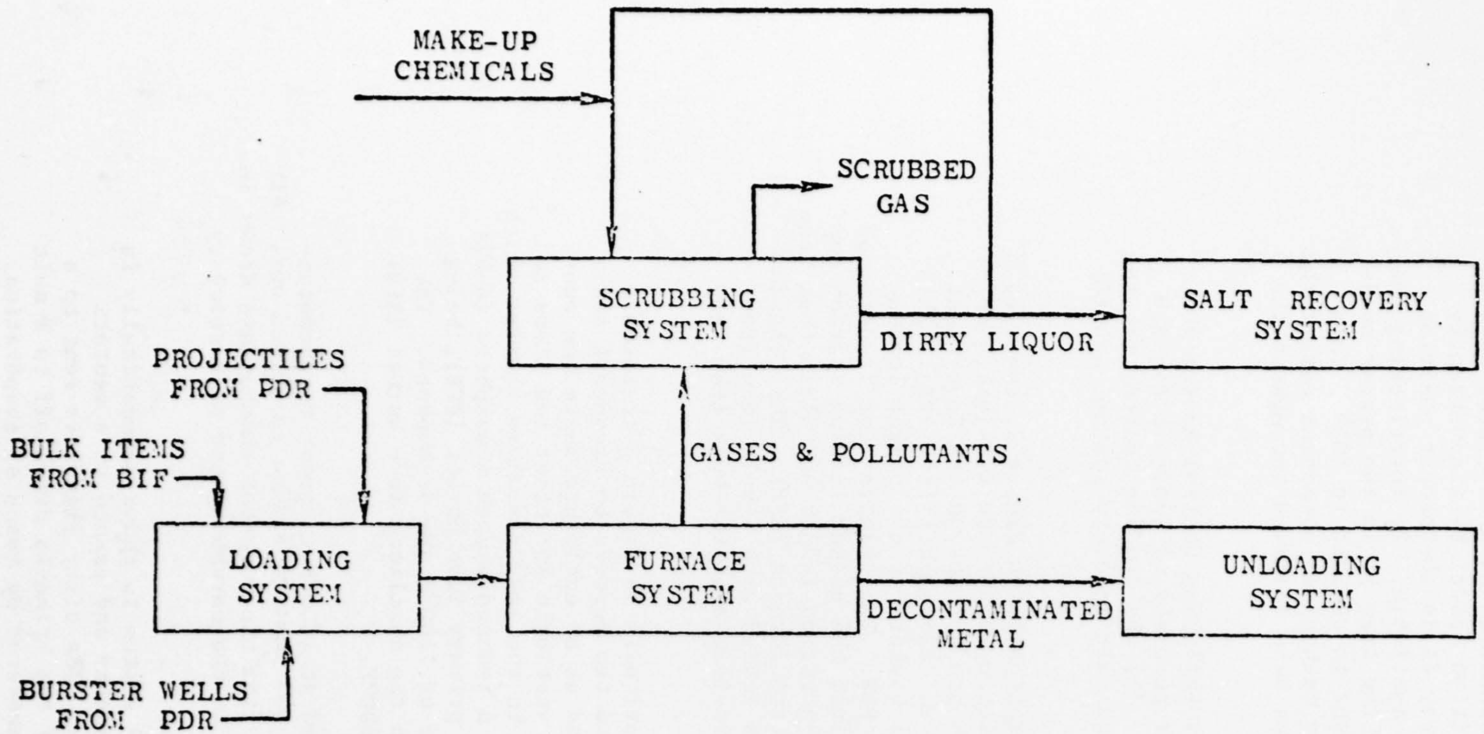

Figure 1. Schematic of Metal Parts Furnace and Air Pollution Control System

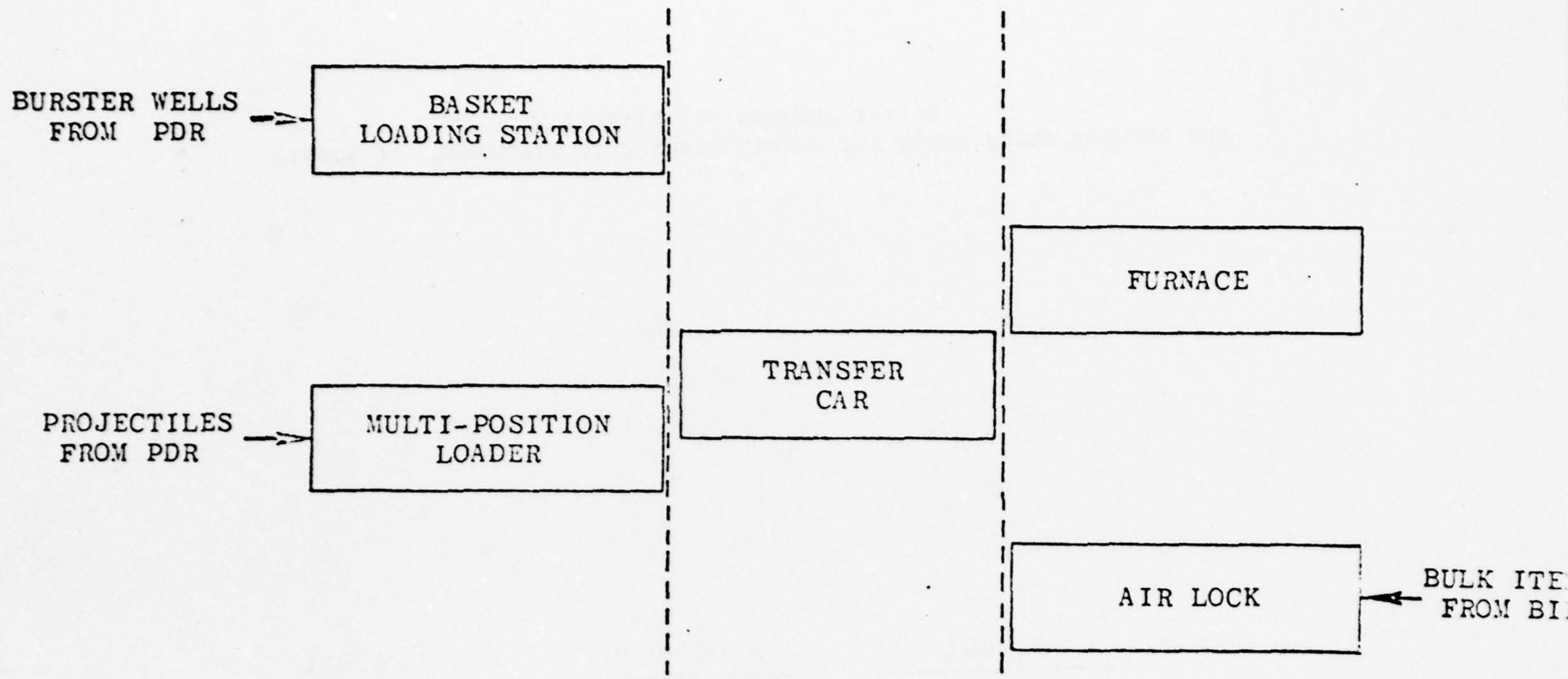

Figure 2. Schematic of Loading System for Metal Parts Furnace and Air Pollution Control System

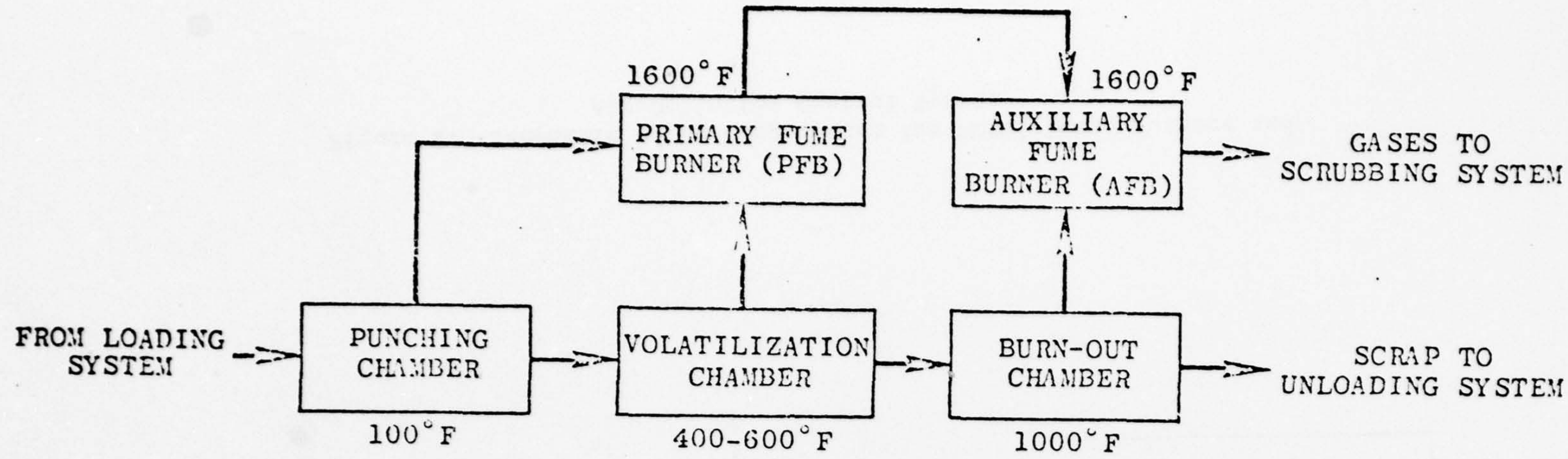

Figure 3. Schematic of Furnace System for Metal Parts Furnace and Air Pollution Control System

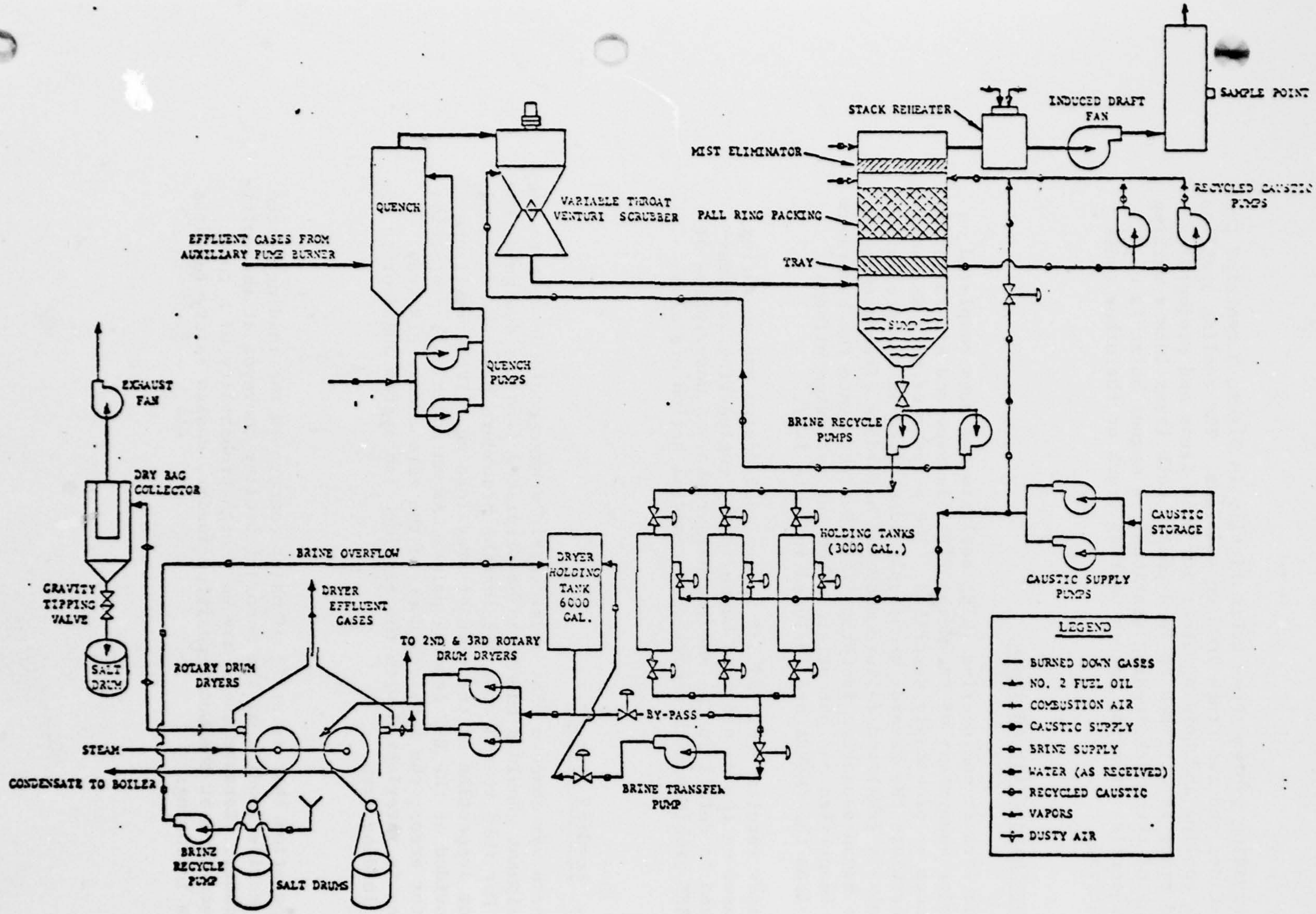

Figure 4. Schematic of Scrubbing and Salt Recovery Systems for Metal Parts Furnace and Air Pollution Control System

The unloading system shown schematically in Figure 5 contains two cooling stations and two truck loading stations. The cooling stations are used as cooling and holding areas for bulk items and projectiles. An overhead crane is utilized to load cooled bulk items into a waiting truck at one of the truck loading stations. A magnet hoist is used to dump projectiles or scrap into a waiting truck at the other truck loading station.

Human Factor Engineering Analysis

A human factors engineering (HFE) analysis has been completed on the four major subsystems of the Metal Parts Furnace and Air Pollution Control System as previously described. The purpose of this HFE analysis was to interrelate the hazards previously identified in the preliminary hazards analysis (PHA) and failure mode and hazardous effects analysis (FM&HEA) to human causative factors.[1,2] For reference the hazardous situations identified and potential system and subsystem effects determined from the FM&HEA are included in Table I-XI.

The major results achieved and recommended design and operating criteria based on the hazards and human factor engineering analyses are discussed in detail in the ensuing paragraphs. A description of remaining HFE problems with recommended remedial action are also included.

A. Loading System

There was concern that considerable damage could be done to the furnace equipment should a bulk item be displaced from its designed tray position. For this reason, the BIF loading procedure has been designed for operator inspection at the time of tray loading. TV surveillance is also provided at the BIF loading point. As an additional protection from operator error, the air-lock door to the zero change BIF tray loading area is interlocked with the air-lock fan system and door to to the MPF loading area.

The operation that is still of major concern in the loading system is the projectile loading by the monorail trolley conveyor at the multi-position loader. Because there may be a high probability of a toxic spillage occurring at the multi-position loader, design safety features include the following:

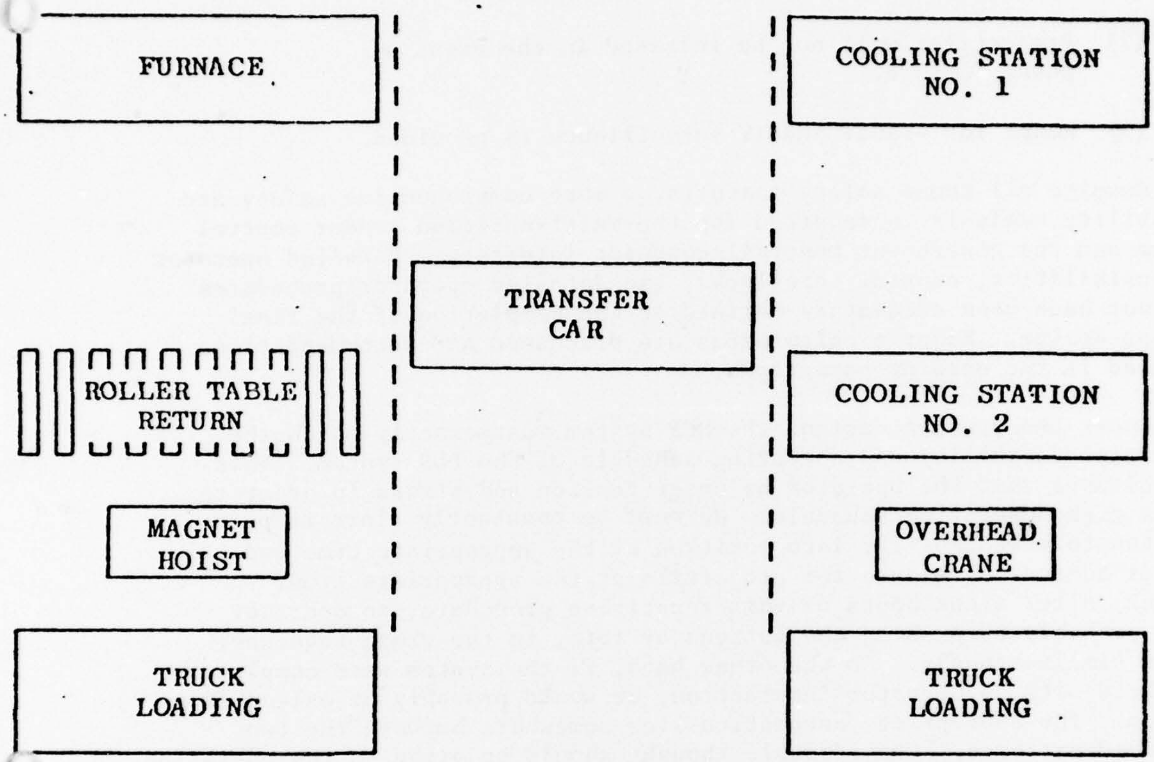

Figure 5. Schematic of Unloading System for Metal Parts Furnace and Air Pollution Control System

(1) An interlock is provided to ensure that the projectile tray is in the proper position before the projectile is released.

(2) Projectiles will not be released in the event of power failure.

(3) Means for visual and TV surveillance is provided.

Despite all these safety features, a more comprehensive safety and reliability analysis is required for the multi-position loader control system and the government monorail conveyor interface. Detailed operator responsibilities, control interlocks, and detailed operator procedures will not have been adequately defined at the completion of the final concept design. Major problem areas are discussed and recommendations proposed in the ensuing paragraphs.

Under the present design, the MPF system must exactly match the production capability and operating schedule of the PDR system. This necessitates that the operator be under tension and stress in order to meet a tight operating schedule. He must be constantly alert to push a button to move the tray into position at the appropriate time and another button to release the projectile at the appropriate time. However, after eight hours of this repetitive procedure, an operator would probably be pushing the buttons by rote, in the wrong sequence, and/or simultaneously. On the other hand, if the system were completely automated with no operator interaction, he would probably be asleep from boredom. The appropriate automation lies somewhere between the two described extremes. Considerable thought should be given to the operating procedures at the monorail conveyor multi-position loader interface. Some suggested procedures are as follows:

(1) Only one button control should be necessary to release the projectile and to reposition the tray.

(2) Repositioning of the tray should be interlocked to the release of the projectile and to a sensing device that indicates the projectile is properly positioned on the tray.

(3) Satisfactory release of projectile into the first row position of the tray should result in automatic loading of projectiles for the remainder of the row. Operator would have to initiate the filling of the first slot in the next row.

The documented hazard analysis fact sheet from the FM&HEA for the loading system is presented in Table I.

B. Furnace System

A major concern during the evolution of the concept design for the furnace was that an equipment damaging explosion could occur if a bulk item were passed from the punching chamber to the volatilization chamber without being punched. Although the majority of the furnace processing operations are automatic, the punching operation should be operator initiated with appropriate interlocks to safeguard against human error. Design safety features include a tray position limit switch interlocked to the punch and an alarm set to the punch travel length to ensure that it has traveled an appropriate length. TV monitors and adequate lighting are provided for visual surveilance. To avoid damage to the furance rollers, the anvil lift is also interlocked to the punch mechanism.

An equipment damaging explosion could also occur if an explosive mustard vapor-air mixture were ignited. Since the above incident is most likely to occur, if at all, during the punching operation, a collar is placed over the bulk item during the punching operation in order to vent mustard vapors or any spray from pressurized containers to the primary fume burner (PFB). A controlled air-flow will also sweep the punching chamber in order to keep mustard-vapor air concentration below the explosive limit (LEL) of approximately 1.3 volume percent mustard. The following additional recommendations are also made:

(1) The volatilization chamber must be cleared prior to proceding with the punching operation.

(2) The visual observance of a fire resulting from the punching operation should require the bulk item to be immediately sent to the volatilization chamber.

TABLE I

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Loading System

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis [illegible]
1. Projectile spill at multi-position loader.	A. Mechanical failure.	Contaminate area.	Shutdown and maintenance. Potential personnel exposure to toxic material	III	5×10^{-4}		Safety and reliability analysis of multi-position loader control system required. Multi-position loader and government mono rail conveyor interface needs to be analyzed.
	B. Operator error and failure of interlock.				5×10^{-8}	Interlock provided to ensure tray in position before release of projectile. Visual and TV surveillance provided.	
	C. Primary and emergency power failure.				1×10^{-10}	Power failure will mean failure to release projectile.	
2. Bulk item fails to be secured to tray.	Holding mechanism fails and operator fails to notice.	--	Potential equipment damage. Shutdown & maintenance. Toxic material release. Potential injury to personnel.	III	2×10^{-9}	BIF loading procedure designed to enable operator inspection at time of tray loading. TV surveillance is also provided.	---

It should be emphasized at this point that the implementation of sophisticated interlock safety systems, such as that described and recommended for the punching operation, does not remove the potential of a system damaging incident from the very same cause for which a safety system was designed to prevent. The interrelationships between the human operator and the system operation must be considered. The concern with such a system as described above is that there is the possibility of operating or maintenance personnel defeating the interlock as a "temporary fix" when some component of the interlock system malfunctions. It is impossible to ensure that such an event will not occur. However, this event probability can be reduced if the following recommendations are implemented:

(1) Do not permit operators access to the control panel electronics.

(2) Instruct maintenance personnel to require proper functioning of the safety interlock system at all times. The identification of a safety interlock malfunction should require postponement of operation until satisfactory repairs can be made.

(3) Establish a checklist of all system critical interlocks, and periodically check and test each item on this list to ensure that it is capable of proper operation. (Optimum test time could be established from availability and maintainability study of final design.)

Many safety features, other than those already discussed, have been designed into the furnace system to ensure that processing can be accomplished safely and to provide a means of safe emergency shutdown in the event of trouble. Despite this fact, a more comprehensive safety and reliability analyses is required for the automated furnace operational control and emergency backup systems. Overall detailed design philosophy will not have been established for the control system at the completion of the concept design; i.e., completely separate emergency backup system, amount of diversity, single, 1 out of 2 or 2 out of 3 voting systems, etc. As a result of the toxic and lethal nature of the materials being processed and the serious consequences which could potentially occur to personnel, environment and/or equipment, a detailed safety and reliability analysis is required to determine the degree and sophistication of automation in order to optimize the total system with respect to safety, cost and reliability.

Numerous potentially hazardous situations have been identified for the furnace system during the FM&HEA and the design safety features provided and/or action or analyses required are given in detail in hazard analysis fact sheets. These documented hazard analysis fact sheets for the furnace system are presented in Tables II through V.

TABLE II

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Punching Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis
1. Anvil fails to lift from roller when punch operates.	Interlock fails when punch operated.	Damage furnace rollers.	Shutdown and maintenance.	II	5×10^{-5}	Anvil lift interlocked to punch mechanism.	
2. Hydraulic punch fails to completely open container.	Interlock fails and operator fails to notice.	---	Incomplete burning of mustard. Explode container.	III	5×10^{-8}	Tray position limit switch interlocked to punch. Alarm set to punch travel length which is measured by follower mounted to hydraulic cylinders. TV monitors and lighting provided.	
3. Mustard spill when bulk item punched.	Bulk item contains mustard under high pressure and collar not engaged and operator fails to notice.	Toxic material spill. Source of explosive mustard - air mixture.	Potential personnel injury during shutdown and maintenance.	III	5×10^{-10}	Punch collar vented to PFB will be engineered to fit closely over ton container in order to reduce frequency of potential problem. Decontamination solution available in loading area.	
4. Vapor-explosion.	Due to 3 above with ignition.	Equipment damage. Toxic material release. Potential personnel injury.	Shutdown and maintenance.	III	$<5 \times 10^{-10}$	Punch collar vented to PFB will be engineered to fit closely over ton container in order to safely control any vapor release. Temperature monitor provided to ensure temperature below flash point. Controlled air-flow sweep provided during processing.	Provide fire arresters (screens) in vents from punching chamber to PFB. Clear volatilization chamber prior to punch operation.
5. Inner or outer door impacts container.	Mechanical failure and interlock limit switch fails.	Equipment damage. Toxic spill.	Shutdown and maintenance. Personnel exposure to toxic material.	III	5×10^{-9}	Automatic sequencing of doors provided. TV monitors provided. Fail-safe locking mechanisms provided for power failure.	
6. Unable to move tray	Roller seized, chain drive broken.	Inability to complete cycle.	Shutdown and maintenance.	II	5×10^{-4}	Manual means for roller hearth drive provided.	

TABLE III

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Volatilization Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis [illegible]
1. Burner goes out.	A. Fuel line plugged due to blockage of filters.	Condense toxic vapors.	Shutdown & maintenance.	III	1×10^{-8}	Double filters provided. Low temperature alarm provided. UV flame detector provided. Independent control system provided for burners.	Attempt to relight if PFB and AFB remain lit.
	B. Lose combustion air due to failure of blowers.				1×10^{-6}	Redundant blowers provided. Push button relight provided.	Automatically switch to redundant blower. Attempt to relight if PFB and AFB remain lit.
	C. Fuel supply not filled on schedule and failure of operator to take action.				1×10^{-6}	Check fuel supply on a regularly scheduled basis.	Automatically switch to emergency fuel supply. Attempt relight if PFB and AFB remain lit.
2. Failure purge system.	Lose steam and pressure switch fails.	Unable to reduce oxygen percentage.	Loss of purge for emergency shutdown. Shutdown & maintenance.	III	5×10^{-8}	Steam purge tied into emergency power and water provided. Steam pressure switch with interlock to furnace operation provided.	
3. Temperature high.	Temperature control system fails and independent high temperature shutdown system fails.	Damage to equipment.	Shutdown & maintenance.	III	1×10^{-8}	High temperature alarm with steam addition provided. High-high temperature automatic purge with fog spray and shutdown provided.	
4. Punch or burn-out chamber doors open during vaporization.	Operator error and interlock fails.	Allows excess air. Possible explosion.	Toxic vapors condense in punching chamber. Flammable mustard-air mixture propagates explosion.	III	5×10^{-8}	Doors to be interlocked and sequenced. Manual switches to be inoperative during automatic operation. Panel board display to be provided.	

TABLE III (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Volatilization Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Required
5. Container or shell falls from tray.	Holding mechanism fails and operator fails to notice.	Jam roller mechanism.	Shutdown & maintenance.	II	2×10^{-9}	Inspection procedure provided at BIF. TV monitors provided in punching chamber.	
6. Unable to move tray through process.	Roller seized, chain drive broken.	Inability to complete cycle.	Shutdown & maintenance.	II	5×10^{-4}	Manual means for roller hearth drive provided.	

ABLE IV

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Burn-out Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Result
1. Burner goes out.	A. Fuel line plugged due to blockage of filters.	Failure to decontaminate metal. Possible condensation of toxic vapors.	Shutdown & maintenance.	II	1×10^{-8}	Double filters provided. Low temperature alarm provided. UV detector provided.	Attempt to relight. Otherwise follow normal shutdown procedure.
	B. Lose combustion air due to failure of blowers.				1×10^{-6}	Redundant blowers provided. Push button relight provided.	Automatically switch to redundant blower. Same as 1A.
	C. Fuel supply not filled on schedule and failure of operator to take action.				1×10^{-6}	Emergency fuel supply provided. Low and high level alarms provided to fuel supply tanks.	Automatically switch to emergency fuel supply. Same as 1A. Check fuel supply on a regularly scheduled basis.
2. Insufficient air added to ensure complete burnout of sludge.	Air supply system fails and operator fails to notice.	Failure to completely burn mustard sludge.	Exposure of personnel to contaminated containers.	II	1×10^{-6}	Air flow indicator provided. Sparge air provided for ton-containers.	
3. Temperature high.	Temperature control system fails and independent high temperature automatic system shutdown fails.	Damage to equipment.	Shutdown & maintenance.	II	1×10^{-8}	High temperature alarm and steam addition provided. High-high temperature automatic system shutdown with fog spray provided.	
4. Temperature low.	Temperature control system fails and operator fails to take action.	Failure to decontaminate metal.	Shutdown & maintenance. Potential personnel exposure to contaminated metal.	II	1×10^{-7}	Temperature recorder provided. Low-temperature alarm provided.	Operator and supervisor must record and ensure certification.

TABLE IV (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Burn-out Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Required
5. Inner or outer door impacts container.	Mechanical failure and door interlock limit switch fails.	Equipment damage.	Shutdown & maintenance.	II	5×10^{-9}	Automatic sequencing of doors provided. Fail-safe locking mechanisms provided for power failure.	
6. Unable to move tray through process.	Roller seized, chain drive broken.	--	Shutdown & maintenance.	II	5×10^{-4}	Manual means for roller hearth drive provided.	

TABLE V

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Primary Fume and Auxiliary Fume Burners

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Requir
1. Burner goes out.	A. Fuel line plugged due to blockage of filters.	--	Shutdown & maintenance. Toxic vapor release.	III	1×10^{-8}	Double filters provided. Low temperature alarm provided. UV flame detector provided.	Follow emergency shutdown procedure.
	B. Lose combustion air due to failure of blowers.				1×10^{-6}	Redundant blower provided.	Follow emergency shutdown procedure.
	C. Fuel supply not filled on schedule and operator fails to take action.				1×10^{-6}	Emergency fuel supply provided. Low and high level alarms provided to fuel supply tanks.	Follow emergency shutdown procedure.
2. Temperature high.	Temperature control system fails and independent high temperature automatic system shutdown fails.	Damage to equipment.		III	1×10^{-8}	High temperature alarm and steam addition to volatilization chamber provided. High-high temperature automatic purge with fog spray to volatilization chamber and furnace shutdown provided.	
3. Temperature low.	Temperature control system fails and independent low temperature automatic system shutdown fails.	Failure to decompose toxic vapors.	Release toxic vapors.	III	1×10^{-8}	Low temperature alarm and steam addition to volatilization chamber provided. Low-low temperature automatic purge with fog spray to volatilization chamber and furnace shutdown provided.	Follow emergency shutdown procedure.

C. <u>Scrubbing and Salt Recovery System</u>

The item of major concern in the scrubbing and salt recovery system is that there will be a release of toxic material to the atmosphere should the system fail to function as designed. For this reason, design safety features include but are not limited to:

(1) Monitors for effluent stack gases.

(2) Emergency power for the induced draft fan with an automatic system purge and shutdown for failure.

(3) Emergency power and standby redundancy for the principal process pumps.

(4) Numerous flow, level, pressure, and temperature alarms and interlocks.

As a safety feature to prevent the possibility of toxic material leaving the pollution system, the spent brine from the packed scrubber tower is sent to retention tanks for certification prior to being pumped to the salt dryer feed tank and from there to the salt recovery system. To minimize the probability of an operator simply forgetting to have the contents of a tank analyzed, it is suggested that the sampling operation and certification be acknowledged by the operator and/or supervisor on a production log prior to allowing the pumping of contents to the salt dryer feed tank.

Hazardous situations identified in the FM&HEA for the scrubbing and salt recovery system and the design safety features provided and/or action or analyses required are documented in hazard analysis fact sheets. These fact sheets are included in Tables VI through X.

As is the case with the furnace system, a safety and reliability analysis should be performed in order to optimize system design. Particular attention should be paid to those areas where the result of failure causes an emergency shutdown for the furnace system.

.BLE VI

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: **Scrubbing and Salt Recovery System - Quench**

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Rec...
1. High quench temperature.	A. Quench brine pump fails and automatic system shutdown fails.	Fail to cool hot gases.	Potential equipment damage.	III	5×10^{-8}	Standby quench brine pump provided. Low pressure alarm provided.	Provide indication for loss of power to quench brine pump. Switch to standby pump.
	B. Quench brine pump control valve fails and automatic system shutdown fails.				1×10^{-7}	Remote manually operated. control valve provided in parallel. Low flow alarm provided.	Manually open remote control valve.
	C. Quench make-up control valve fails and automatic system shutdown fails.				1×10^{-7}	Standby emergency water available. Remote manually operated control valve provided in parallel.	Provide low flow alarm. Manually open remote control valve.
	D. Primary and emergency power failure and failure of emergency water supply.				1×10^{-13}	Emergency power provided. Emergency water supply made available on loss of commercial power. Emergency water control valve fails open on loss of power.	Make emergency water supply independent of utility failure; i.e., water tower.
	E. Component failures and failure of automatic system shutdown.*				5×10^{-5}	High temperature alarm provided. High temperature automatic system shutdown provided.	Open full quench brine pump control valve upon high temperature alarm.

* Worst case analysis where probability of component failure causing high quench temperature equals one and high temperature automatic system shutdown fails.

TABLE VI (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Quench

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Rec
2. Overfill quench tower.	A. Plugged quench return and automatic system shutdown fails.	---	Brine to AFB system shutdown & maintenance.	II	5×10^{-9}	High level alarm provided. High level automatic system shutdown provided. Level gage provided.	Manually reduce flow of quench brine through remote control valve.
	B. Emergency water control valve fails and automatic system shutdown fails.				1×10^{-7}		Manually close off emergency water supply. Provide annunciator to show control valve is open. Provide for automatic shutdown.
	C. Primary and emergency power failure and automatic system shutdown failure.				5×10^{-15}	Automatic system shutdown provided.	---
3. Empty quench tower of liquid.	A. Quench level control valve sticks open and automatic shutdown fails.	Allow gas to bypass quench.	Potential equipment damage. Shutdown and maintenance.	III	1×10^{-7}	Low level alarm provided. Low level automatic system shutdown provided. Level gage provided.	Manually adjust control valve via controller. Manually operate block and globe valves at site.
	B. Level control valve from scrubbing tower sticks open and automatic system shutdown fails.	Empty scrubbing tower.	Lose quench and venturi flow.		1×10^{-7}	Low level alarm provided for scrubbing tower. Low level automatic system shutdown provided.	Manually adjust control valve via controller. Manually operate block and globe valves at site.
	C. Quench brine pump fails and automatic system shutdown fails.				5×10^{-8}	Standby quench brine pump provided.	Same as 1-A.

TABLE VII

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Venturi

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis [illegible]
1. No or insufficient brine flow to venturi.	A. Venturi slurry pump fails and operator fails to take action.	Lost or reduced venturi scrubbing capability.	Failure to meet pollution standards. Potential toxic release. Shutdown & maintenance.	III	1×10^{-6}	Standby venturi slurry pump provided. Low pressure alarm provided.	Provide indication for loss of power to venturi slurry pump. Switch to standby pump.
	B. Loss of commercial power and failure of automatic system shutdown.				5×10^{-10}	Emergency power provided to quench venturi slurry pump. Provision for automatic system shutdown for loss of commercial power.	
	C. Venturi flow control valve fails and operator fails to take action				3×10^{-6}	Low flow alarm for control valve provided.	Manually operate globe valve at site.
2. Improperly adjusted venturi throat.	A. Throat closed too much or plugged and operator fails to take action.	---	Pressurize furnace. Potential toxic release.	III	1×10^{-6}	High differential pressure alarm provided.	Manually open throat via controller at site.

TABLE VIII

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Scrubbing Tower

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Required
1. Overfill scrubbing tower.	A. Purge pump fails & automatic system shutdown fails.		System shutdown and maintenance.	II	5×10^{-9}	Standby purge pump provided. Low pressure alarm provided.	Switch to standby pump.
	B. Suction line plugged & automatic system shutdown fails.				5×10^{-9}	Low pressure alarm provided.	
	C. Control valve to retention tank fails closed & automatic system shutdown fails.				1×10^{-7}	Bypass valve provided.	Manually operate bypass valve.
	D. Component failures and failure of automatic system shutdown*				5×10^{-5}	High level alarm provided. High level automatic system shutdown provided.	
2. Empty scrubbing tower.	Level control valve sticks open & automatic system shutdown fails.		Lose quench and venturi flows. System shutdown and maintenance. Potential equipment damage.	III	1×10^{-7}	Low level alarm provided. Low level automatic system shutdown provided.	Adjust control valve via controller.
3. Plug scrubbing tower.	Demister section plugged & operator fails to take action.	Reduce demisting efficiency.	Pressurize furnace. Potential toxic release. Shutdown and maintenance.	III	1×10^{-7}	High differential alarm for demister section provided. Remote operator rinse-monitor provided.	Operate rinse-monitor. Provide for excessive pressure system shutdown.
4. Loss of caustic scrubbing capability.	A. Caustic pump fails and operator fails to take action.	No fresh caustic.	Shutdown and maintenance. Failure to meet emissions standards. Loss of caustic scrubbing capability.	III	1×10^{-6}	Standby caustic pump provided. Low pressure alarm provided.	Switch to standby pump. Provide indication for loss of power to caustic pump.

* Worst case analysis where probability of component failure causing scrubbing tower to overfill equals one and high level automatic system shutdown fails.

TABLE VIII (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Scrubbing Tower

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Req.
	B. pH caustic control valve fails and operator fails to take action.				3×10^{-6}	Low pH alarm provided bypass globe valve provide.	Adjust control valve via controller. Manually operate globe bypass valve at site.
5. Reduced scrubbing efficiency	A. Tower clean liquor pump fails & operator fails to take action.	---	Shutdown & maintenance.	II	1×10^{-6}	Standby clean liquor pump provided. Low pressure alarm provided.	Switch to standby pump.
	B. Control valve fails & operator fails to take action.				3×10^{-6}	Bypass valve provided.	Operate bypass valve.
	C. Suction line plugged and operator fails to take action.				1×10^{-7}	Low pressure alarm provided. Remote control valve provided.	Intermittently open and close remote control valve.
6. Excessive CO_2 scrubbing.	Caustic pH control valve fails open & operator fails to take action.	Excess caustic added.	Shutdown & maintenance.	II	3×10^{-6}	High pH alarm provided.	Manually adjust control valve via controller.
7. Loss of pH control.	pH sample pump fails. Suction line plugged and operator fails to take action.		Shutdown & maintenance.	II	1×10^{-6}	Standby pH sample pump provided. Low pressure alarm provided.	Switch to standby pump.

TABLE IX

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Retention, Salt Dryer Feed, and Caustic Supply Tanks.

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis [illegible]
1. Overfill retention, salt dryer feed or caustic tanks.	Supply control valve fails open and operator fails to take action.	Spill caustic.	Potential maintenance. Potential personnel injury during maintenance.	II	3×10^{-6}	High level alarm provided. Automatic shutdown of control valve provided. Manual shut-off valves provided after control valve.	Provide overflow sump or drain. Manually operate shut-off valve at site.
2. Empty caustic supply tank.	Failure caustic pH control valve and operator fails to take action.	--	Lose caustic scrubbing capability. Failure to meet emission standards. Shutdown.	II	3×10^{-6}	Low level alarm provided. Low pH alarm provided. Remotely operated caustic supply valve provided.	Open remotely operated caustic supply valve.

TABLE X

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Drum Dryers

Potential Problem	Failure Mode	Effect		Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis [illegible]
		Subsystem	System				
1. Lose steam to a drum dryer.	Control valve failure.	Failure to dry salts.	Shutdown & maintenance.	I	3×10^{-3}		Shut off failed dryer. Shut off feed to failed dryer.
2. High temperature in drum dryers.	Temperature control system fails.	Damage to equipment.	Shutdown & maintenance.	II	Nil	High temperature not possible with 125 psi steam supply.	
3. Loss of rotation to a drum dryer.	Drive motor failure.		Shutdown & maintenance.	I	1×10^{-3}		Shut off steam supply to failed dryer. Shut off feed to failed dryer.
4. Dust explosion.	Presence of fine dust and minimum ignition source.	Potential equipment damage.	Shutdown & maintenance. Potential personnel injury.	III	1×10^{-6}		Provide adequate dust collection system. Ground equipment. Provide enclosed bearings.

D. Unloading System

An item of major concern was that operator error could result in toxic vapor being released from the furnace to the zero air change unload area. The opening of the outer burn-out chamber door when the furnace is not under negative pressure could cause the release of toxic vapor. To avoid this problem, the outer combustion door is interlocked to the burn-out chamber draft control. As an added precaution, it is recommended that the SOP for opening the outer combustion door during processing requires visual verification of instrumentation to ensure the burn-out chamber is under negative pressure.

Another concern is that scrap not sufficiently processed in the MPF could lead to a contamination of the zero air change unload area and to the exposure of personnel to toxic material. To avoid this problem, a temperature recorder and low temperature alarm is provided for the burn-out chamber so that an operator and/or supervisor could verify that the material leaving the furnace has been heated for the appropriate time at the required metal soak temperature. To minimize the probability of human error, it is suggested that the operator and/or supervisor keep a production log establishing furnace processing conditions.

TABLE XI

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Unloading System

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re[illegible]
1. Toxic vapor in zero change unload area.	Failure of fan and failure of differential pressure interlock and operator error.	Contaminate zero change area.	Potential personnel exposure to toxic material.	III	1×10^{-10}	Outer combustion door interlocked with differential pressure switch to prevent opening without minimum draft differential.	
2. Contaminated scrap in zero change unload area.	Temperature control for MPF burn-out chamber fails and operator does not notice.	Contaminate zero change area.	Potential personnel exposure to toxic material.	III	1×10^{-7}	A temperature recorder and low temperature alarm provided.	Adopt and execute quality control procedures. Recycle items failing to meet acceptable standards.

REFERENCES

1. Hercules Incorporated, " Preliminary Hazards Analysis of a Metal Parts Furnace and Air Pollution Control System," M. J. Katz, Report No. A08207-520-03-004, July 12, 1974.

2. Hercules Incorporated, "Failure Mode and Hazardous Effects Analysis of a Metal Parts Furnace and Air Pollution Control System," M. J. Katz, Report No. A08207-520-03-008, September 4, 1974.

3. Human Factors Engineering, McCormick, E. J., McGraw-Hill, Inc., 1970.

4. Hercules in-house data.

5. "Why Do People Drop Things," Rigby, L. U., "Quality Progress," 1973.

6. Fixed Ground Equipment, Park X, Failure Rate Data Handbook, Hughes Aircraft Company, RADC-TR-69 -458, Final Technical Report, March, 1970.

APPENDIX B

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FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

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FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

- DIGEST -

Objective

The technical objective of this program is the design of a Metal Parts Furnace (MPF), a subsystem of a Chemical Agents/Munitions Disposal System. In accordance with government regulations, a failure mode and hazardous effects analysis (FM&HEA) has been completed on the final concept design. A preliminary hazards analysis (PHA) had been performed on the initial concept design to identify specific events (toxic leaks, explosions, equipment failure and operator error) which could pose a hazard to personnel, equipment, or environment. This FM&HEA for the final concept design is an extension of the PHA in order to update the PHA to include the latest design parameters and to expand the previous study to include the severity of hazards.

Results and Conclusions

For purposes of this safety analysis, the Metal Parts Furnace and Air Pollution Control System were divided into the following four subsystems: (1) the loading system, (2) the furnace system, (3) the scrubbing and salt recovery system, and (4) the unloading system. Numerous specific events (toxic leaks, explosions, equipment failure, and operator error) which could pose a hazard to personnel, equipment or the environment were identified and documented for each of these four subsystems.

Many safety and reliability features have been designed into the MPF system to ensure that processing can be accomplished safely at the designed production capacity and to provide a means of a safe emergency shutdown in the event of trouble. Numerous potentially hazardous situations have been identified for the MPF system and the design safety features provided and/or action or analysis required are given in detail in the hazard analysis fact sheets contained in this report.

References will be made throughout this report to suggested system changes or operational limits that should serve as a useful guide in optimizing the system from the standpoint of safety, cost, and reliability. The safety recommendations which are in addition to those safety design features already included in the final concept design are summarized below:

(1) Holding capacity for loaded projectile trays should be provided in the loading area and maintenance and operation scheduled so MPF operation is not affected by minor breakdowns of the Pull Drain and Rinse Facility (PDR) or monorail conveyor systems.

(2) Flame arresters (screens) should be placed in the vent line from the punching chamber to the primary fume burner (PFB) to prevent a possible flash back from the PFB.

(3) The punching operation should require visual surveillance and operator action to initiate it.

(4) The volatilization chamber must be cleared prior to proceeding with the punching operation.

(5) The visual observance of a fire resulting from the punching operation should require the bulk item to be immediately sent to the volatilization chamber.

(6) Provide an overflow line for the quench tower to either a sump or holding tank in order to prevent possibility of brine reaching the AFB.

Recommended Future Work

1. A more comprehensive safety and reliability analysis is recommended for the multi-position loader and government monorail conveyor interface since detailed operating procedures and control interlocks will not be adequately defined at the completion of the final concept design phase.

2. A thorough hazard analysis of the final detailed engineering and installation design is recommended.

3. A fault tree and reliability analysis is recommended for the automated control system.

- INTRODUCTION -

This is the Failure Mode and Hazardous Effects Analysis (FM&HEA) report for the Hazards and Risk Analysis of a Metal Parts Furnace (MPF), a subsystem of the Chemical Agent/Munitions Disposal System (CAMDS) under prime contract DAAA51-74-C-0092, PO Number 066741-0 and Job Number PC-1259-1.

A preliminary hazards analysis (PHA) had been performed on the initial concept design for the MPF system in order to identify and report specific events (toxic leaks, explosions, equipment failure and operator error) which could pose a hazard to personnel, equipment, or environment. The primary objective of the preliminary hazard analysis effort was to provide the basis for the formulation of subsequent system safety tasks, criteria, and requirements. This FM&HEA for the final concept design is an extension of the PHA in order to update the preliminary hazards analysis to include the latest design parameters and to expand the previous study to include the severity of hazards.

A reliability failure mode and effect analysis which is often performed in conjunction with a FM&HEA was not included in this safety study. Sufficient design data to adequately perform this quantitative type analysis will not be available until the completion of the final engineering design. Nevertheless, the system safety analysis techniques employed for the hazard evaluation of the final concept design do meet current Army requirements[1,2,3] which specify that a systems hazards analysis be employed so that conclusions and recommendations can be made to eliminate or control hazardous conditions. This safety analysis and hazard evaluation report of the MPF system final concept design, as specified in DI-H-1326, includes the following information:

(1) Identification of possible hazardous components, hazardous operations and emergency conditions through the contemplated life cycle.

(2) Evaluation of contemplated safety related equipment, safeguards, operations and possible alternate approaches.

(3) Evaluation and listing of the relative corrective action priorities of the various safety related problems and considerations identified.

A thorough hazard analysis of the final detailed engineering and installation design should be performed. The hazard evaluation should include the actual installation of equipment and startup of the plant. Special attention should be given to a system analysis of the control system, including a fault tree and reliability analysis.

- DISCUSSION OF RESULTS -

System Description

The Metal Parts Furnace and Air Pollution Control System shown schematically in Figure 1 can be for purposes of analysis divided into the following four subsystems: (1) the loading system, (2) the furnace system, (3) the scrubbing and salt recovery system, and (4) the unloading system.

The loading system, shown schematically in Figure 2, contains a basket loading station, a multi-position loader, an air-lock, and a transfer car. Trays are loaded with projectiles on the Government monorail system from the Pull Drain and Rinse Facility (PDR). This same monorail system is used to fill baskets at the basket loading station with burster wells from the PDR. The transfer car is designed to accept baskets of burster wells from the basket loading station and trays of projectiles from the multi-position loader and place them into the punching chamber of the metal parts furnace (MPF). The transfer car is also designed to accept trays loaded with a bulk item (ton container or spray tank) from the air-lock over the bulk item tray return conveyor.

The furnace system shown schematically in Figure 3 contains a three chamber metal parts furnace and two fume burners to decompose toxic vapors. The punching chamber is used as an enclosure where ton containers are punched or as a holding vestibule for other end items to be processed. Mustard is vaporized in the volatilization chamber which is maintained from 400-600^{o}F and at a reduced oxygen atmosphere (4-6%). The vapors which are drawn into the primary fume burner (PFB), being controlled at a constant temperature of 1600^{o}F are decomposed. The decomposition gases are then sent to the auxiliary fume burner (AFB) which is also being controlled at 1600^{o}F.

The burn-out chamber is operated at 1000^{o}F in order to decontaminate the metal parts and to ensure all mustard sludge is burned out. Air is supplied to this chamber. Gases from the burn-out chamber are drawn into the AFB and from there exhausted to the scrubbing and salt recovery system.

The scrubbing and salt recovery system is shown schematically in Figure 4. The furnace gases are quenched and passed to a venturi scrubber for removal of particulates. The dirty liquor is sent to a packed scrubber tower. A portion of the brine is drawn off to a salt recovery system where the salt is recovered by means of evaporation. The remaining brine is recycled to the venturi scrubber. Scrubbed gases are drawn up the stack and released to the atmosphere.

The unloading system shown schematically in Figure 5 contains two cooling stations and two truck loading stations. The cooling stations are used as cooling and holding areas for bulk items and projectiles. An overhead crane is utilized to load cooled bulk items into a waiting truck at one of the truck loading stations. A magnet hoist is used to dump projectiles or scrap into a waiting truck at the other truck loading station.

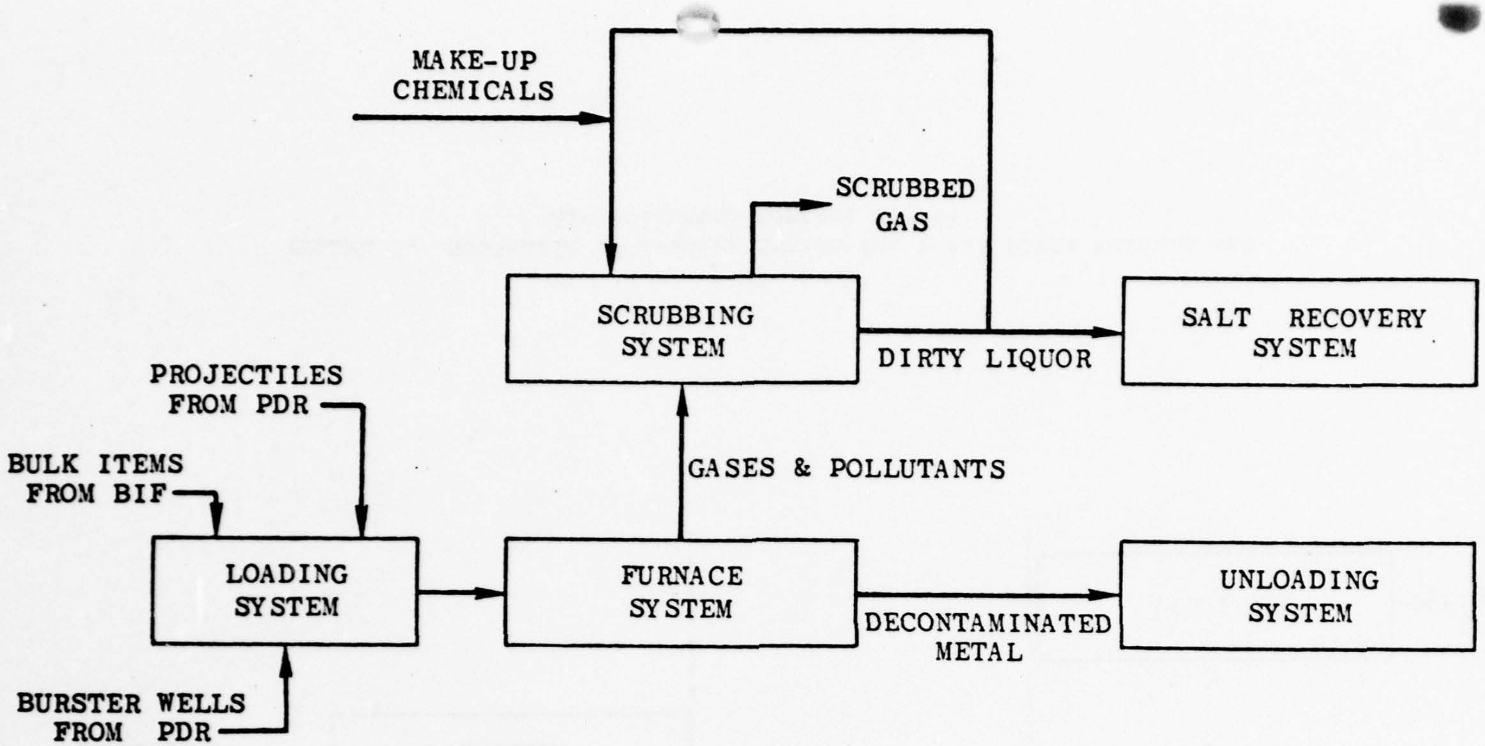

Figure 1. Schematic of Metal Parts Furnace and Air Pollution Control System

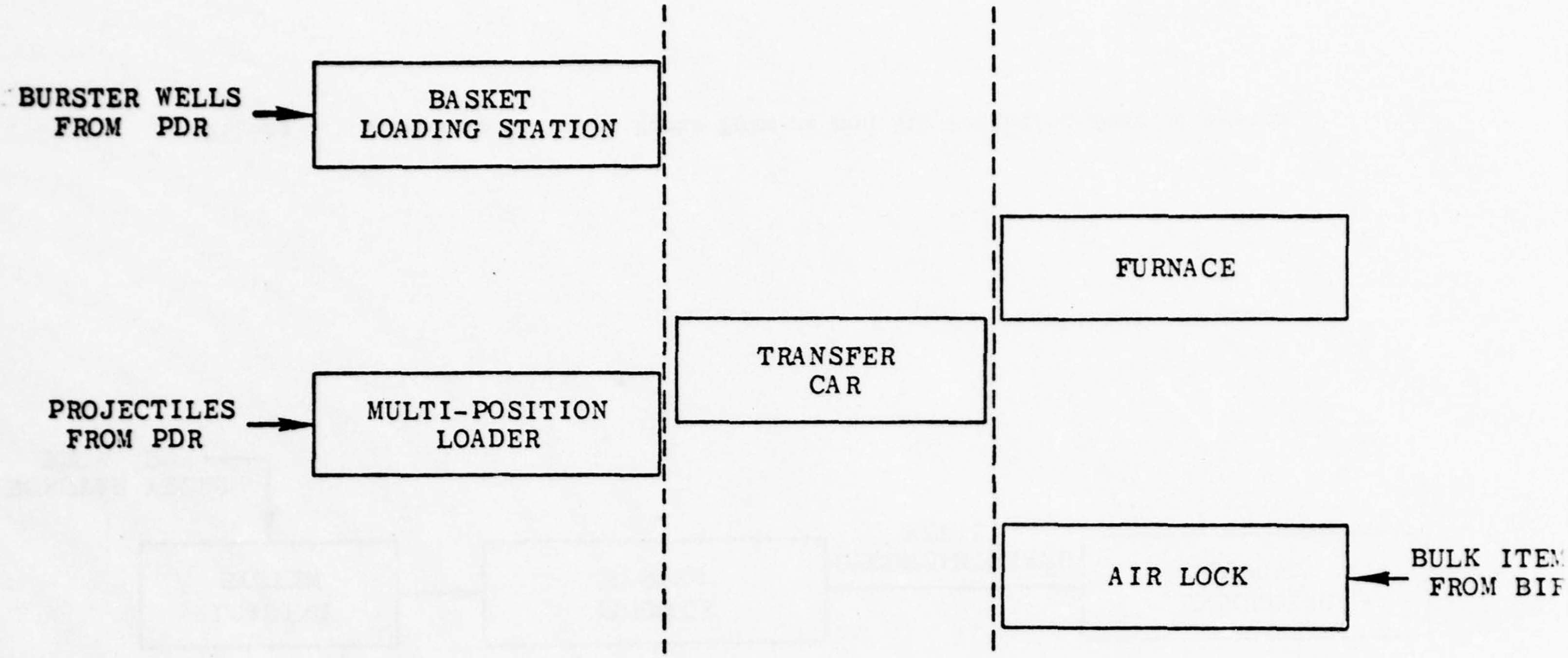

Figure 2. Schematic of Loading System for Metal Parts Furnace and Air Pollution Control System

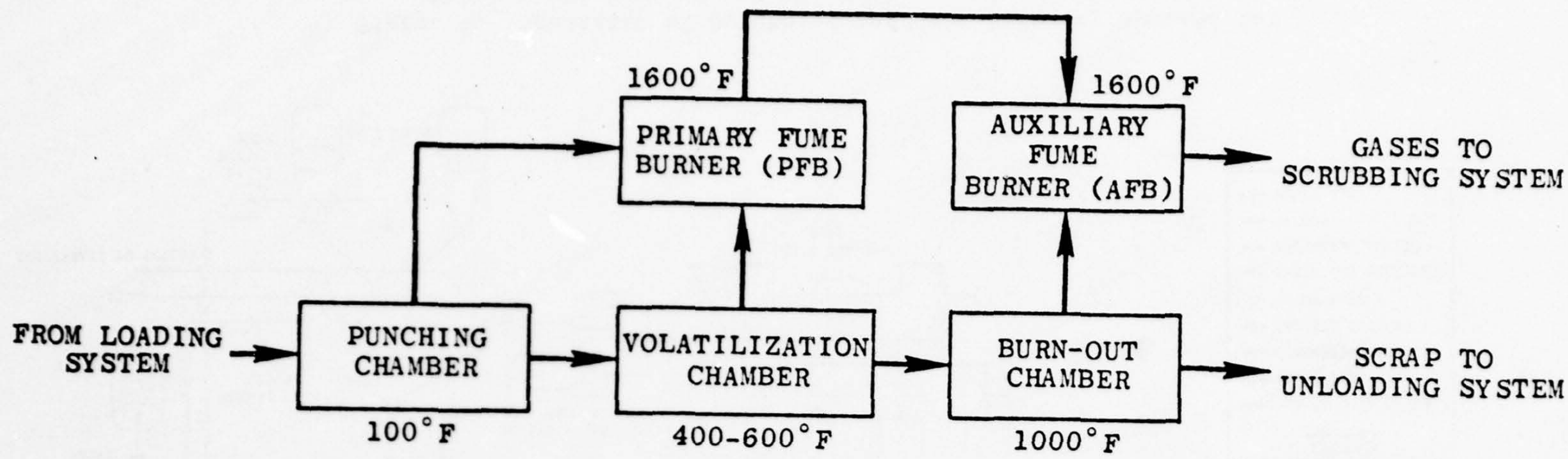

Figure 3. Schematic of Furnace System for Metal Parts Furnace and Air Pollution Control System

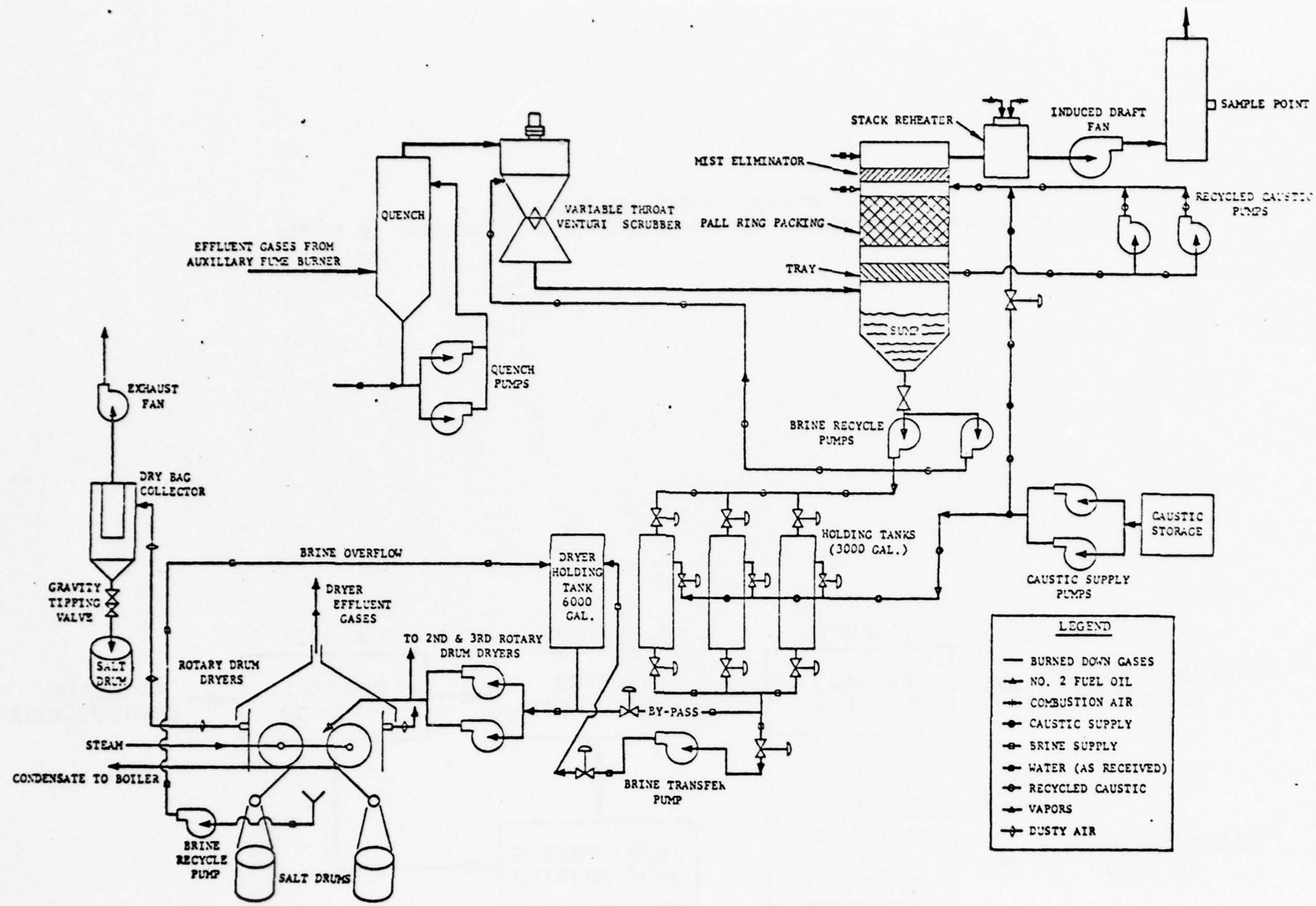

Figure 4. Schematic of Scrubbing and Salt Recovery Systems for Metal Parts Furnace and Air Pollution Control System

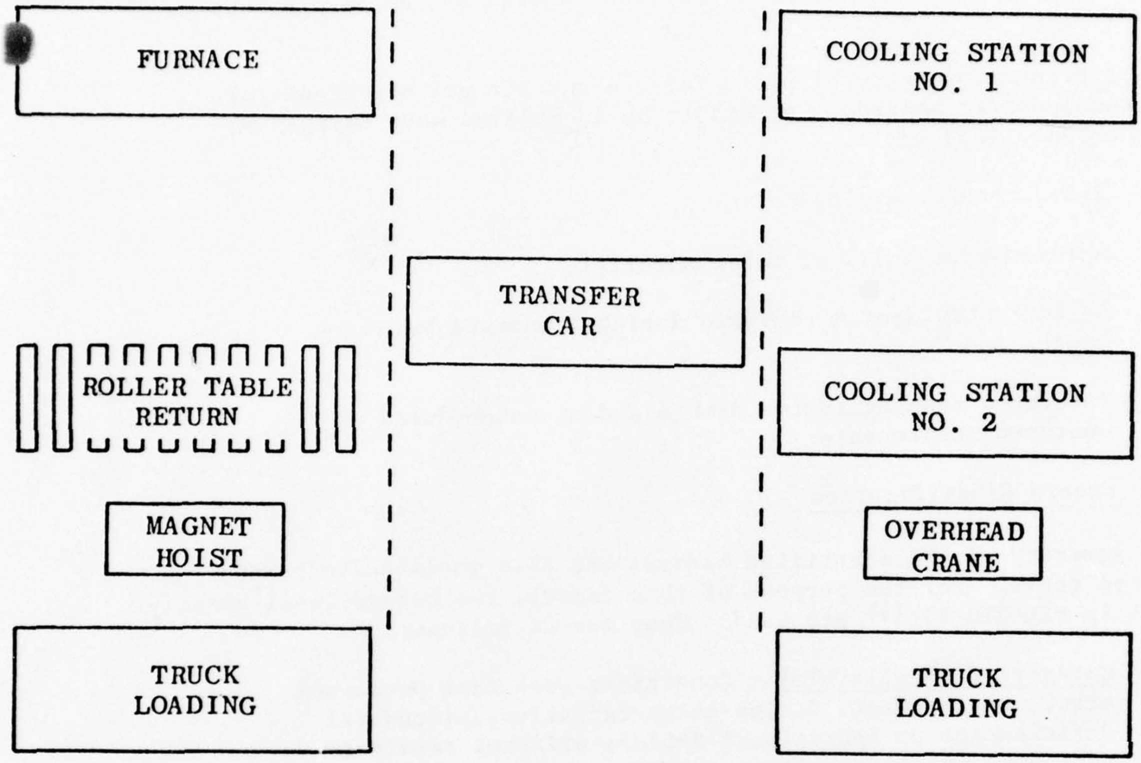

Figure 5. Schematic of Unloading System for Metal Parts Furnace and Air Pollution Control System

Hazard Evaluation

A hazard evaluation has been completed on the four major subsystems of the Metal Parts Furnace and Air Pollution Control System as previously described.

In reference to the metal parts furnace and air pollution control system, the specific hazardous events to be identified were defined as those that could lead to:

(1) A fire and/or explosion,

(2) A release or spill of toxic material,

(3) An emergency system shutdown during a mustard burn cycle, and

(4) Incidents causing system damage and/or unscheduled shutdown maintenance.

A. Hazard Classification

The severity of the identified hazards was also qualitatively measured in relative terms. For the purpose of this report, the hazard level classifications in MIL-STD-882[1] are used. They are as follows:

(1) Category I (Negligible) - Conditions such that personnel error, environment, design characteristics, procedural deficiencies or operational failure will not result in personnel injury or system damage. These operations are considered inherently safe or have identifiable hazards that are readily eliminated through design.

(2) Category II (Marginal) - Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or operational failure can be counteracted or controlled without injury to personnel or major system damage. These are operations where hazards can be eliminated or controlled to an acceptable limit so as to not seriously injure personnel or cause major system damage.

(3) Category III (Critical) - Conditions such that personnel error, environment, design characteristics, procedural deficiencies, or operational failure will cause personnel injury or major system damage, or will require immediate corrective action for personnel or system survival. These operations present hazards that cannot be eliminated, but can be reduced by rigid control or procedures, operator training in safety and redundant controls or interlocks. Resultant incidents may cause severe personnel injury or major system damage.

(4) Category IV (Catastrophic) - Conditions such that personnel error, environment, design characteristics, procedural deficiencies or operational failure will cause death or severe injury to personnel or system loss.

B. Probabilistic Analysis

The FMHEA is a quantitative hazards analysis in that the frequency of occurrence of the identified hazards is determined for a specific period of operation. The operating time between maintenance intervals was taken as the time frame to determine the frequency of occurrence. For a five day, 20 hour per day work schedule with maintenance on weekends, the reference time is 100 hours..

This analysis studies the frequency of occurrence of hazardous events and evaluates whether or not these events would result in a release or spill of toxic material or in a fire and/or explosion. The analysis, is thus, a multistep procedure, considering what component failures or operator errors must occur in order for the hazardous event to occur.

The probabilistic evaluation concept is extremely important in that the events do not in themselves result in a catastrophy. They are merely one link in a chain of events that may result in a catastrophy. The probability of a serious incident (P_{SE}) which could lead to injury or death to personnel is the product of the event probability times the probability of toxic or explosive material being present times the probability of personnel being exposed, that is

$$P_{SE} = P_E \times P_M \times P_{EX}$$

where:

P_{SE} = probability of serious event

P_E = probability of potentially hazardous event

P_M = probability of toxic or explosive material being present

P_{EX} = probability of personnel exposure to toxic release or explosive incident

The above conditional probability model was utilized to perform a quantitative safety analysis for the MPF system. The ensuing section describes in detail how the model was utilized to perform this analysis.

1. Probability of Event (P_E)

Probabilities used in the determination of frequency of events are in one of two classifications: time dependent or time independent.

Time dependent components utilize failure rates, expressed as failures per million operating hours. For example, a failure rate of 5×10^{-6} means that, for the component in question, the average number of failures to be expected is five per million operating hours. These failure rates may be found in data banks such as FARADA (4) or ROME (5). Although the reliability of any failure rate data may be of questionable value, the failure rates obtained from the data banks are realistic in that these rates were tabulated from actual operating records. Tabulated data also include the component test environment, i.e., rocket, aircraft, ship, ground, or laboratory.

Depending upon its severity, the operating environment may reduce or increase the failure rate.

The probability for non-time dependent events, such as operations involving people, is dependent upon the type of incident. These events are independent of time and the probability applies every time the operation is performed.

The probabilities for different operator activities are:

Type of Incident	Probability
(1) Error of Procedure	1×10^{-3} per event
(2) Dropping an item	1×10^{-4} per event
(3) Accidental Condition	
a. Extreme labor intense*	1×10^{-3} per event
b. Moderate labor intense**	1×10^{-4} per event
c. All other conditions	1×10^{-5} per event
(4) Foreign Object is Present	1×10^{-4} per event

* Extreme labor intense operations are those whereby one operator may bump a second operator during normal operating activities. These conditions are most frequently found in older assembly type production systems.

** Moderate labor intense operations are characterized by having two, or at most three operators in close confinement. Maintenance operations in the MPF were assumed to be in this Category. These data were obtained from actual operating records as well as reports in the literature(6).

2. Probability Material is Present (P_m)

The probability that combustible or toxic material is present (P_m) has one of the three probabilities:

(1) The probability is 1.0 for a normal occurrence such as mustard in an unprocessed ton container.

(2) The probability is 1×10^{-3} that there will be sufficient contamination or agent present due to operator error in procedure such as an analytical error. The probability is 1×10^{-5} to 1×10^{-3} for accidental operator error, depending on stress of the situation.

(3) The probability is time dependent for such events as failure of a control valve resulting in a hazardous situation being formed.

For purposes of this analysis any exposure of personnel to an explosive incident and/or a toxic material, i.e., and/or VX or GB agent is assumed to result in serious injury or death. Thus, the probability of personnel exposure has been assigned a value of 1 in order to be a "worst case analysis."

System Analysis

The hazardous situations identified with potential system and subsystem effects, hazard level category, frequency of occurrence, design safety features for prevention, and recommendations are listed in Tables I through XI and are discussed in detail in the ensuing paragraphs.

A. Loading System

Items of major concern in the loading system are the projectile loading by the monorail trolley conveyor at the multi-position loader, and the loading of bulk items at BIF-loading system air-lock.

There is considerable concern that there may be a high probability of a toxic spillage occurring at the multi-position loader. For this reason design safety features include the provision of an interlock to ensure that the projectile tray is in the proper position before the projectile is released. Power failure will mean failure to release the projectile. Visual and TV surveillance will be provided. Nevertheless, a more comprehensive safety and reliability analysis is required for the multi-position loader control system and the government monorail conveyor interface. Detailed operator responsibilities, control interlocks, and detailed procedures will not be adequately defined at the completion of the final concept design phase.

There is serious concern that a PDR-MPF system will not meet the projected availability; i.e., designed production capacity for various projectile end items, simply because of the sophistication and complexity of the system. Under the present design, the MPF system must exactly match the production capability and operating schedule of the PDR system. If the PDR system should break down, the MPF system would be idled an equivalent time. It is for this reason that is recommended that a holding capacity for loaded projectile trays be provided in the loading area and that maintenance and operation be scheduled such that MPF operation is not affected by minor breakdowns of the PDR or monorail conveyor system. The acceptance of this recommendation will provide (1) more flexibility of operation, (2) allow space to be allocated for loaded projectile trays that have to be removed from the furnace in an emergency situation, and (3) help relieve tension and stress of loading operator who would have to otherwise meet a tight processing schedule.

There can be considerable damage done to the furnace equipment should a bulk item be displaced from its designed tray position. For this reason, the BIF loading procedure has been designed to enable operator inspection at the time of tray loading. TV surveillance is also provided at the BIF loading point. For protection to personnel, the air-lock door to the zero change BIF tray loading area is interlocked with the air-lock fan system and door to the MPF loading area.

The documented hazard analysis fact sheet for the loading system is presented in Table I.

B. Furnace System

For purposes of analysis, the furnace system has been divided into the following four subsystems:

(1) the punching chamber,

(2) the volatilization chamber,

(3) the burn-out chamber, and

(4) the primary and auxiliary fume burners.

An equipment damaging explosion could occur if a bulk item were passed from the punching chamber to the volatilization chamber without being punched. For this reason, design safety features include a tray position limit switch interlocked to the punch, and an alarm set to the punch travel length to ensure that the punch has traveled an appropriate length. To avoid damage to the furnace rollers, the anvil lift is interlocked to the punch mechanism. TV monitors and adequate lighting are also provided for visual surveillance.

An equipment damaging explosion could also occur if an explosive vapor-air mixture were ignited. For this reason a collar is placed over the bulk items so that mustard vapors or any spray from pressurized containers are vented to the primary fume burner (PFB). Clean out pans or troughs are provided in the bottom of the punching chamber in the event of a mustard spill. A controlled air-flow will also sweep the punching chamber in order to keep the mustard vapor-air concentration below the lower explosive limit (LEL) of approximately 1.3 volume percent mustard (see Appendix A). As an additional safety precaution, the temperature of the punching chamber will be monitored to ensure that the temperature is below the flash point ($105^{o}C$ for minimum specification grade agent HD).

The following additional safety recommendations are made:

(1) Flame arresters (screens) should be placed in the vent line from the punching chamber to the primary fume burner (PFB) to prevent a possible flash back from the PFB.

TABLE I

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Loading System

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re...
1. Projectile spill at multi-position loader.	A. Mechanical failure.	Contaminate area.	Shutdown and maintenance. Potential personnel exposure to toxic material	III	5×10^{-4}		Safety and reliability analysis of multi-posit... loader control system required. Multi-positi... loader and government ... rail conveyor interface needs to be analyzed.
	B. Operator error and failure of interlock.				5×10^{-8}	Interlock provided to ensure tray in position before release of projectile. Visual and TV surveillance provided.	
	C. Primary and emergency power failure.				1×10^{-10}	Power failure will mean failure to release projectile.	
2. Bulk item fails to be secured to tray.	Holding mechanism fails and operator fails to notice.	--	Potential equipment damage. Shutdown & maintenance. Toxic material release. Potential injury to personnel.	III	2×10^{-9}	BIF loading procedure designed to enable operator inspection at time of tray loading. TV surveillance is also provided.	---

(3) The punching operation should require visual surveillance and operator action to initiate it.

(4) The volatilization chamber must be cleared prior to proceeding with the punching operation.

(5) The visual observance of a fire resulting from the punching operation should require the bulk item to be immediately sent to the volatilization chamber.

The loss of a burner system can result in a hazardous situation (release of toxic material) requiring an emergency shutdown and/or unscheduled maintenance. For this reason, the following safety design features have been included:

(1) Redundant combustion air blowers, redundant oil pump and filter systems, and an emergency fuel supply are included in the burner design.

(2) Two independent burner control systems are provided for the volatilization burners.

(3) Low temperature and low-low temperature automatic shutdown alarm systems are provided for the burn-out chamber, primary fume burner (PFB), and auxiliary fume burner (AFB).

(4) High temperature and high-high temperature automatic shutdown alarm systems are provided for the volatilization chamber, burn-out chamber, PFB and AFB.

Many safety features,other than those already discussed, have been designed into the furnace system to ensure that processing can be accomplished safely and to provide a means of a safe emergency shutdown in the event of trouble. Numerous potentially hazardous situations have been identified for the furnace system and the design safety features provided and/or action or analysis required are given in detail in the hazard analysis fact sheets.

The documented hazard analysis fact sheets for the furnace system are presented in Tables II through V.

C. Scrubbing and Salt Recovery System

For purposes of analysis, the scrubbing and salt recovery system has been divided into the following subsystems:

TABLE II

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Punching Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re[illegible]
1. Anvil fails to lift from roller when punch operates.	Interlock fails when punch operated.	Damage furnace rollers.	Shutdown and maintenance.	II	5×10^{-5}	Anvil lift interlocked to punch mechanism.	
2. Hydraulic punch fails to completely open container.	Interlock fails and operator fails to notice.	---	Incomplete burning of mustard. Explode container.	III	5×10^{-8}	Tray position limit switch interlocked to punch. Alarm set to punch travel length which is measured by follower mounted to hydraulic cylinders. TV monitors and lighting provided.	
3. Mustard spill when bulk item punched.	Bulk item contains mustard under high pressure and collar not engaged and operator fails to notice.	Toxic material spill. Source of explosive mustard - air mixture.	Potential personnel injury during shutdown and maintenance.	III	5×10^{-10}	Punch collar vented to PFB will be engineered to fit closely over ton container in order to reduce frequency of potential problem. Decontamination solution available in loading area.	
4. Vapor-explosion.	Due to 3 above with ignition.	Equipment damage. Toxic material release. Potential personnel injury.	Shutdown and maintenance.	III	$<5 \times 10^{-10}$	Punch collar vented to PFB will be engineered to fit closely over ton container in order to safely control any vapor release. Temperature monitor provided to ensure temperature below flash point. Controlled air-flow sweep provided during processing.	Provide fire arresters (screens) in vents fr[illegible] punching chamber to PF[illegible] Clear volatilization chamber prior to punch operation.
5. Inner or outer door impacts container.	Mechanical failure and interlock limit switch fails.	Equipment damage. Toxic spill.	Shutdown and maintenance. Personnel exposure to toxic material.	III	5×10^{-9}	Automatic sequencing of doors provided. TV monitors provided. Fail-safe locking mechanisms provided for power failure.	
6. Unable to move tray	Roller seized, chain drive broken.	Inability to complete cycle.	Shutdown and maintenance.	II	5×10^{-4}	Manual means for roller hearth drive provided.	

TABLE III

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Volatilization Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re[illegible]
1. Burner goes out.	A. Fuel line plugged due to blockage of filters.	Condense toxic vapors.	Shutdown & maintenance.	III	1×10^{-8}	Double filters provided. Low temperature alarm provided. UV flame detector provided. Independent control system provided for burners.	Attempt to relight if P[illegible] and AFB remain lit.
	B. Lose combustion air due to failure of blowers.				1×10^{-6}	Redundant blowers provided. Push button relight provided.	Automatically switch to redundant blower. Atte[illegible] to relight if PFB and A[illegible] remain lit.
	C. Fuel supply not filled on schedule and failure of operator to take action.				1×10^{-6}	Check fuel supply on a regularly scheduled basis.	Automatically switch to emergency fuel supply. Attempt relight if PFB [illegible] AFB remain lit.
2. Failure purge system.	Lose steam and pressure switch fails.	Unable to reduce oxygen percentage.	Loss of purge for emergency shutdown. Shutdown & maintenance.	III	5×10^{-8}	Steam purge tied into emergency power and water provided. Steam pressure switch with interlock to furnace operation provided.	
3. Temperature high.	Temperature control system fails and independent high temperature shutdown system fails.	Damage to equipment.	Shutdown & maintenance.	III	1×10^{-8}	High temperature alarm with steam addition provided. High-high temperature automatic purge with fog spray and shutdown provided.	
4. Punch or burn-out chamber doors open during vaporization.	Operator error and interlock fails.	Allows excess air. Possible explosion.	Toxic vapors condense in punching chamber. Flammable mustard-air mixture propagates explosion.	III	5×10^{-8}	Doors to be interlocked and sequenced. Manual switches to be inoperative during automatic operation. Panel board display to be provided.	

TABLE III (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Volatilization Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re[illegible]
5. Container or shell falls from tray.	Holding mechanism fails and operator fails to notice.	Jam roller mechanism.	Shutdown & maintenance.	II	2×10^{-9}	Inspection procedure provided at BIF. TV monitors provided in punching chamber.	
6. Unable to move tray through process.	Roller seized, chain drive broken.	Inability to complete cycle.	Shutdown & maintenance.	II	5×10^{-4}	Manual means for roller hearth drive provided.	

TABLE IV

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Burn-out Chamber

Potential Problem	Failure Mode	Effect		Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re[illegible]
		Subsystem	System				
1. Burner goes out.	A. Fuel line plugged due to blockage of filters.	Failure to decontaminate metal. Possible condensation of toxic vapors.	Shutdown & maintenance.	II	1×10^{-8}	Double filters provided. Low temperature alarm provided. UV detector provided.	Attempt to relight. Oth[illegible] wise follow normal shutd[illegible] procedure.
	B. Lose combustion air due to failure of blowers.				1×10^{-6}	Redundant blowers provided. Push button relight provided.	Automatically switch to redundant blower. Same as 1A.
	C. Fuel supply not filled on schedule and failure of operator to take action.				1×10^{-6}	Emergency fuel supply provided. Low and high level alarms provided to fuel supply tanks.	Automatically switch to emergency fuel supply. Same as 1A. Check fuel supply on a regularly scheduled basis.
2. Insufficient air added to ensure complete burnout of sludge.	Air supply system fails and operator fails to notice.	Failure to completely burn mustard sludge.	Exposure of personnel to contaminated containers.	II	1×10^{-6}	Air flow indicator provided. Sparge air provided for ton-containers.	
3. Temperature high.	Temperature control system fails and independent high temperature automatic system shutdown fails.	Damage to equipment.	Shutdown & maintenance.	II	1×10^{-8}	High temperature alarm and steam addition provided. High-high temperature automatic system shutdown with fog spray provided.	
4. Temperature low.	Temperature control system fails and operator fails to take action.	Failure to decontaminate metal.	Shutdown & maintenance. Potential personnel exposure to contaminated metal.	II	1×10^{-7}	Temperature recorder provided. Low-temperature alarm provided.	Operator and supervisor must record and ensure certification.

TABLE IV (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Burn-out Chamber

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re...
5. Inner or outer door impacts container.	Mechanical failure and door interlock limit switch fails.	Equipment damage.	Shutdown & maintenance.	II	5×10^{-9}	Automatic sequencing of doors provided. Fail-safe locking mechanisms provided for power failure.	
6. Unable to move tray through process.	Roller seized, chain drive broken.	--	Shutdown & maintenance.	II	5×10^{-4}	Manual means for roller hearth drive provided.	

TABLE V

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Furnace System - Primary Fume and Auxiliary Fume Burners

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis R[illegible]
1. Burner goes out.	A. Fuel line plugged due to blockage of filters.	--	Shutdown & maintenance. Toxic vapor release.	III	1×10^{-8}	Double filters provided. Low temperature alarm provided. UV flame detector provided.	Follow emergency shutdown procedure.
	B. Lose combustion air due to failure of blowers.				1×10^{-6}	Redundant blower provided.	Follow emergency shutdown procedure.
	C. Fuel supply not filled on schedule and operator fails to take action.				1×10^{-6}	Emergency fuel supply provided. Low and high level alarms provided to fuel supply tanks.	Follow emergency shutdown procedure.
2. Temperature high.	Temperature control system fails and independent high temperature automatic system shutdown fails.	Damage to equipment.		III	1×10^{-8}	High temperature alarm and steam addition to volatilization chamber provided. High-high temperature automatic purge with fog spray to volatilization chamber and furnace shutdown provided.	
3. Temperature low.	Temperature control system fails and independent low temperature automatic system shutdown fails.	Failure to decompose toxic vapors.	Release toxic vapors.	III	1×10^{-8}	Low temperature alarm and steam addition to volatilization chamber provided. Low-low temperature automatic purge with fog spray to volatilization chamber and furnace shutdown provided.	Follow emergency shutdown procedure.

(1) quench,

(2) venturi,

(3) scrubbing tower,

(4) retention, salt dryer feed, and caustic supply tanks, and

(5) drum dryer.

An item of major concern in the scrubbing and salt recovery system is that there will be a release of toxic material to the atmosphere should the system fail to function as designed. For this reason, design safety and reliability features include, but are not limited to: (1) monitors for effluent stack gases, (2) emergency power for the induced draft fan with an automatic system purge and shutdown for failure, (3) emergency power to the purge pump, quench brine return pump, slurry pump, clean liquor pump, PH sample pump, and the instrumentation and analytical train, (4) redundant pumps other than product pump, and (5) numerous flow, level, pressure, and temperature alarms and interlocks.

Another item of concern is that there is a possibility of overfilling the quench tower so that brine can pass to the AFB system. Although a high level alarm and automatic system shutdown are provided, it is also recommended that an overflow line be provided to either a sump or retention tank in order to prevent the possibility of brine reaching the AFB system.

Other potentially hazardous events identified for the scrubbing and salt recovery system and the design safety features provided and/or action or analysis required are given in detail in the hazard analysis fact sheets.

The documented hazard analysis fact sheets for the Scrubbing and Salt Recovery System presented in Tables VI through X.

D. Unloading System

An item of major concern was that toxic vapor could be released from the furnace to the zero air change unload area. The opening of the outer burn-out chamber door when the furnace is not under negative pressure could cause the release of toxic vapor. To avoid this problem, the outer combustion door is interlocked to the burn-out chamber draft control.

Another concern was that scrap not sufficiently processed in the MPF could lead to a contamination of the zero change unload area and to the exposure of personnel to toxic material. To avoid this problem, a temperature recorder and low temperature alarm is provided for the burn-out chamber so that an operator and/or supervisor could verify that the material leaving the furnace has been heated for the appropriate time at the required metal soak temperature.

The documented hazard analysis fact sheet for the unloading system is shown in Table XI.

TABLE VI

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Quench

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis [illegible]
1. High quench temperature.	A. Quench brine pump fails and automatic system shutdown fails.	Fail to cool hot gases.	Potential equipment damage.	III	5×10^{-8}	Standby quench brine pump provided. Low pressure alarm provided.	Provide indication for of power to quench bri[illegible] pump. Switch to standb[illegible] pump.
	B. Quench brine pump control valve fails and automatic system shutdown fails.				1×10^{-7}	Remote manually operated. control valve provided in parallel. Low flow alarm provided.	Manually open remote control valve.
	C. Quench make-up control valve fails and automatic system shutdown fails.				1×10^{-7}	Standby emergency water available. Remote manually operated control valve provided in parallel.	Provide low flow alarm. Manually open remote control valve.
	D. Primary and emergency power failure and failure of emergency water supply.				1×10^{-13}	Emergency power provided. Emergency water supply made available on loss of commercial power. Emergency water control valve fails open on loss of power.	Make emergency water su[illegible] independent of utility failure; i.e., water to[illegible]
	E. Component failures and failure of automatic system shutdown.*				5×10^{-5}	High temperature alarm provided. High temperature automatic system shutdown provided.	Open full quench brine pump control valve upon high temperature alarm.

* Worst case analysis where probability of component failure causing high quench temperature equals one and high temperature automatic system shutdown fails.

TABLE VI (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Quench

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis R[illegible]
2. Overfill quench tower.	A. Plugged quench return and automatic system shutdown fails.	---	Brine to AFB system shutdown & maintenance.	II	5×10^{-9}	High level alarm provided. High level automatic system shutdown provided. Level gage provided.	Manually reduce flow of quench brine through remot control valve.
	B. Emergency water control valve fails and automatic system shutdown fails.				1×10^{-7}		Manually close off emergency water supply. Provide annunciator to show control valve is open. Provide for automatic shutdown.
	C. Primary and emergency power failure and automatic system shutdown failure.				5×10^{-15}	Automatic system shutdown provided.	---
3. Empty quench tower of liquid.	A. Quench level control valve sticks open and automatic shutdown fails.	Allow gas to bypass quench.	Potential equipment damage. Shutdown and maintenance.	III	1×10^{-7}	Low level alarm provided. Low level automatic system shutdown provided. Level gage provided.	Manually adjust control valve via controller. Manually operate block and globe valves at site.
	B. Level control valve from scrubbing tower sticks open and automatic system shutdown fails.	Empty scrubbing tower.	Lose quench and venturi flow.		1×10^{-7}	Low level alarm provided for scrubbing tower. Low level automatic system shutdown provided.	Manually adjust control valve via controller. Manually operate block and globe valves at site.
	C. Quench brine pump fails and automatic system shutdown fails.				5×10^{-8}	Standby quench brine pump provided.	Same as 1-A.

TABLE VII

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Venturi

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis [illegible]
1. No or insufficient brine flow to venturi.	A. Venturi slurry pump fails and operator fails to take action.	Lost or reduced venturi scrubbing capability.	Failure to meet pollution standards. Potential toxic release. Shutdown & maintenance.	III	1×10^{-6}	Standby venturi slurry pump provided. Low pressure alarm provided.	Provide indication for of power to venturi sl[illegible] pump. Switch to stand[illegible] pump.
	B. Loss of commercial power and failure of automatic system shutdown.				5×10^{-10}	Emergency power provided to quench venturi slurry pump. Provision for automatic system shutdown for loss of commercial power.	
	C. Venturi flow control valve fails and operator fails to take action				3×10^{-6}	Low flow alarm for control valve provided.	Manually operate globe valve at site.
2. Improperly adjusted venturi throat.	A. Throat closed too much or plugged and operator fails to take action.	---	Pressurize furnace. Potential toxic release.	III	1×10^{-6}	High differential pressure alarm provided.	Manually open throat vi[illegible] controller at site.

TABLE VIII

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Scrubbing Tower

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re[illegible]
1. Overfill scrubbing tower.	A. Purge pump fails & automatic system shutdown fails.		System shutdown and maintenance.	II	5×10^{-9}	Standby purge pump provided. Low pressure alarm provided.	Switch to standby pump.
	B. Suction line plugged & automatic system shutdown fails.				5×10^{-9}	Low pressure alarm provided.	
	C. Control valve to retention tank fails closed & automatic system shutdown fails.				1×10^{-7}	Bypass valve provided.	Manually operate bypass valve.
	D. Component failures and failure of automatic system shutdown*				5×10^{-9}	High level alarm provided. High level automatic system shutdown provided.	
2. Empty scrubbing tower.	Level control valve sticks open & automatic system shutdown fails.		Lose quench and venturi flows. System shutdown and maintenance. Potential equipment damage.	III	1×10^{-7}	Low level alarm provided. Low level automatic system shutdown provided.	Adjust control valve vi[illegible] controller.
3. Plug scrubbing tower.	Demister section plugged & operator fails to take action.	Reduce demisting efficiency.	Pressurize furnace. Potential toxic release. Shutdown and maintenance.	III	1×10^{-7}	High differential alarm for demister section provided. Remote operator rinse-monitor provided.	Operate rinse-monitor. Provide for excessive pressure system shutdown
4. Loss of caustic scrubbing capability.	A. Caustic pump fails and operator fails to take action.	No fresh caustic.	Shutdown and maintenance. Failure to meet emissions standards. Loss of caustic scrubbing capability.	III	1×10^{-6}	Standby caustic pump provided. Low pressure alarm provided.	Switch to standby pump. Provide indication for loss of power to caustic pump.

*Worst case analysis where probability of component failure causing scrubbing tower to overfill equals one and high level automatic system shutdown fails.

TABLE VIII (CONTINUED)

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Scrubbing Tower

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Req[illegible]
	B. pH caustic control valve fails and operator fails to take action.				3×10^{-6}	Low pH alarm provided bypass globe valve provide.	Adjust control valve via controller. Manually operate globe bypass valve at site.
5. Reduced scrubbing efficiency	A. Tower clean liquor pump fails & operator fails to take action.	---	Shutdown & maintenance.	II	1×10^{-6}	Standby clean liquor pump provided. Low pressure alarm provided.	Switch to standby pump.
	B. Control valve fails & operator fails to take action.				3×10^{-6}	Bypass valve provided.	Operate bypass valve.
	C. Suction line plugged and operator fails to take action.				1×10^{-7}	Low pressure alarm provided. Remote control valve provided.	Intermittently open and close remote control valve.
6. Excessive CO_2 scrubbing.	Caustic pH control valve fails open & operator fails to take action.	Excess caustic added.	Shutdown & maintenance.	II	3×10^{-6}	High pH alarm provided.	Manually adjust control valve via controller.
7. Loss of pH control.	pH sample pump fails. Suction line plugged and operator fails to take action.		Shutdown & maintenance.	II	1×10^{-6}	Standby pH sample pump provided. Low pressure alarm provided.	Switch to standby pump.

TABLE IX

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Retention, Salt Dryer Feed, and Caustic Supply Tanks.

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Req.
1. Overfill retention, salt dryer feed or caustic tanks.	Supply control valve fails open and operator fails to take action.	Spill caustic.	Potential maintenance. Potential personnel injury during maintenance.	II	3×10^{-6}	High level alarm provided. Automatic shutdown of control valve provided. Manual shut-off valves provided after control valve.	Provide overflow sump or drain. Manually operate shut-off valve at site.
2. Empty caustic supply tank.	Failure caustic pH control valve and operator fails to take action.	--	Lose caustic scrubbing capability. Failure to meet emission standards. Shutdown.	II	3×10^{-6}	Low level alarm provided. Low pH alarm provided. Remotely operated caustic supply valve provided.	Open remotely operated caustic supply valve.

TABLE X

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Scrubbing and Salt Recovery System - Drum Dryers

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis Re[illegible]
1. Lose steam to a drum dryer.	Control valve failure.	Failure to dry salts.	Shutdown & maintenance.	I	3×10^{-3}		Shut off failed dryer. Shut off feed to failed dryer.
2. High temperature in drum dryers.	Temperature control system fails.	Damage to equipment.	Shutdown & maintenance.	II	Nil	High temperature not possible with 125 psi steam supply.	
3. Loss of rotation to a drum dryer.	Drive motor failure.		Shutdown & maintenance.	I	1×10^{-3}		Shut off steam supply to failed dryer. Shut off feed to failed dryer.
4. Dust explosion.	Presence of fine dust and minimum ignition source.	Potential equipment damage.	Shutdown & maintenance. Potential personnel injury.	III	1×10^{-6}		Provide adequate dust collection system. Ground equipment. Provide enclosed bearings.

TABLE XI

FAILURE MODE AND HAZARDOUS EFFECTS ANALYSIS OF A METAL PARTS FURNACE AND AIR POLLUTION CONTROL SYSTEM

Subsystem: Unloading System

Potential Problem	Failure Mode	Effect: Subsystem	Effect: System	Hazard Category	Frequency (in 100 hours)	Design Safety	Action or Analysis F[illegible]
1. Toxic vapor in zero change unload area.	Failure of fan and failure of differential pressure interlock and operator error.	Contaminate zero change area.	Potential personnel exposure to toxic material.	III	1×10^{-10}	Outer combustion door interlocked with differential pressure switch to prevent opening without minimum draft differential.	
2. Contaminated scrap in zero change unload area.	Temperature control for MPF burn-out chamber fails and operator does not notice.	Contaminate zero change area.	Potential personnel exposure to toxic material.	III	1×10^{-7}	A temperature recorder and low temperature alarm provided. ---	Adopt and execute quality control procedures. Recycle items failing to meet acceptable standards.

REFERENCES

1. "System Safety Program for Systems and Associated Subsystems and Equipment: Requirements For," MIL-STD-882, July 15, 1969.

2. "Safety Analysis and Hazard Evaluation Reports," DI-H-1326, December 15, 1969.

3. "Safety Manual," AMCR-385-100.

4. Failure Rate Data Handbook FARADA, Naval Fleet Missile System Analysis and Evaluation Group, Corona, California, September 1970.

5. Nonelectronic Reliability Handbook, Rome, Vols. II and III, Section I, Report No. RADC-TR-68-14, Rome Air Development Center, Rome, New York, June 1968.

6. L. U. Rigby, "Why Do People Drop Things?" Quality Process, 1973.

APPENDIX A

The literature [1] indicates for dimethyl sulfide (CH_3SCH_3) that the lower explosive limit LEL in air is 0.5 of stoichiometric and that the upper explosive limit (UEL) is 4.5 times stoichiometric. The balanced equation of mustard to SO_2 is:

$$C_4H_8Cl_2S + 6.5\ O_2 \rightarrow SO_2 + 4\ CO_2 + 2\ HCl + 3\ H_2O$$

On the basis that air is 21% O_2, there would be 6.5/0.21 or 30.95 volumes of air per one volume of mustard, and the stoichiometric composition of mustard would be 1/(1 + 30.95) or 3.1%. Therefore, the estimated explosive air limits would be:

$$\text{LEL} = (.5)\ (3.1) = 1.55\%$$
$$\text{UEL} = (4.5)\ (3.1) = 13.95\%$$

The flash point is also a very good estimate for the LEL. The following table was determined from physical and chemical properties based on minimum specification grade agent HD[2] and a plot of the log of the vapor pressure versus the inverse of the absolute temperature.

	Temperature °C	Vapor Pressure MM Hg
Boiling Point	227.8	760
Flash Point	105	10.5
-	20	0.072

The LEL estimated from the flash point is 10.5/760 = 1.33%

(1) Zabetakis, M.D., "Flammability Characteristics of Combustible Gases and Vapors," Bulletin 627, Bureau of Mines, 1965, P. 74.

(2) AMC Regulation No. AMCR 385-31 "Safety Regulations for Chemical Agents H, HD, and HT," October 1971.